THURSDAY, SEPTEMBER 10, 1891.

AN EVOLUTIONARY CASTIGATION.

Science or Romance? By the Rev. John Gerard, S.J. (London: Catholic Truth Society, 1891.)

THAT the doctrine of evolution should not be as sweet savour in the nostrils of the writer of this little book is in no way surprising, but that he should attack evolutionists and their ways with the weapons of flippancy and ridicule is an encouraging indication that the said doctrine has penetrated into quarters from which the author evidently thinks it high time to eject this modern heresy. Having seized the scourge, Father Gerard accordingly proceeds to lay out all round, delivering his blows with vigour, if not with discrimination, and occasionally throwing such force into his strokes that the lash recoils and strikes the striker. In happy unconsciousness that he hits himself quite as often as he does his adversaries, the author goes on with his flagellation through six essays occupying 136 pages of somewhat close print. Although, as we have said, the attitude taken by the author will cause no astonishment, it is very much to be regretted that he has so far put himself out of harmony with the spirit of modern biological thought as to confuse the opinions, speculations, and working hypotheses of individual exponents of evolution with the broad principles of that doctrine. For, however distasteful it may be to Father Gerard, it is an indisputable fact that the acceptance of that doctrine is well-nigh universal, and the question whether evolution is or is not a *modus operandi* in nature, has passed beyond the phase of discussion among scientific thinkers and workers. So far as the author's attacks are directed against evolution as a principle, his weapon is as a bladder of air against the hide of a hippopotamus. It is satisfactory to find, however, that amidst the whizzing of his *flagellum* the author discerns the still small voice of reason:—

"The one fact given us, is the existence of evidence to show that various species of plants and animals have probably, or possibly, been developed one from another. This, so far as it goes, is matter for scientific treatment; and the theory of evolution, within the limits thus afforded, has a right to be called a scientific hypothesis."

We are grateful for small mercies, and it would be ungracious to inquire too closely into the origin of this concession, but to those who read between the lines it will be apparent that the thirty years' campaign carried on by evolutionists has not been without result, even in the most unpromising fields.

The antagonist whom evolutionists in general and Darwinians in particular have found in the author of the work under consideration is a foeman not altogether unworthy of their steel. He brings into the arena a certain amount of knowledge of living things which indicates that he is an observer of nature in the field. Moreover, he shows some understanding of his subject, and does not fall into the error of substituting blundering misconceptions for the statements of fact or theory which he is combating. Added to this there is a certain keenness of satire running through his essays which adds to their piquancy. The name of Father Gerard on the title-page is a sufficient indication that evolutionists will find death and no quarter in his pages, and the reader will not be disappointed if he turns to these essays with the special object of finding the weaknesses of the modern school exposed. But while the purely destructive attacks of the reverend critic may give satisfaction to those who belong to his school, the impartial reader will derive only amusement, and the man of science will soon perceive that the weapons of attack are not the legitimate implements of scientific warfare, but the tricks of disputation concealed under a somewhat alluring literary cloak, embellished here and there with a few flowers of the author's own culling.

Having arrived at this general estimate of the work, it will not be necessary to do more than take a passing glance at its contents. The first essay, entitled "A Tangled Tale," opens with an attack on natural selection; the author will have none of it; he objects to the term and he denies its efficiency:—

"It would, in fact, be vastly more likely that we should cast aces three hundred times running, with a pair of unloaded dice, or toss 'tails' two thousand times with an honest coin, than that a development should be handed down by natural selection through ten generations, even if we start with so favourable a supposition as that one-half of the offspring tend to vary in the required direction."

This conclusion is based on a calculation in which the whole principle of selection is ignored!

The central idea of this essay is, that evolutionists have reduced the operations of Nature to "chance," "accident," and so forth. We are told, at the very outset:—

"The cardinal point of the doctrine they proclaim is, that no purpose operates in Nature, and that the explanation of everything we see is to be found in the mechanical forces of matter."

In order that there may be no misunderstanding as to what the author means by chance, he defines it as "the coincidence of independent phenomena—that is, of phenomena not co-ordinated to an end." By what criterion, may we ask, are "chance" phenomena, as thus defined, to be distinguished from "pre-determined" phenomena? Prof. Huxley's example, quoted from Darwin's "Life and Letters," is critically dealt with, and the author tells us that this is "utterly wide of the mark. The phenomena here described [a storm at sea] end with themselves, they lead to nothing else; nothing follows from them. They are mere effects, and not, so far as we know, a means to obtain a result beyond." The insight which the author appears to have gained into the motive, or want of motive, in nature is really most enviable; the man of science who must perforce arrive at his conclusions by the circuitous roads of observation and experiment can only look with admiring wonder upon a method which is so completely foreign to his philosophy.

This same dummy, chance, is well belaboured throughout; among the slain, after this first tilt, we find not only Prof. Huxley, but Andrew Wilson, Oscar Schmidt, and, above all, Mr. Grant Allen, whose form is so terribly hacked that he appears to have been in the very centre of the fray, if not the chief object of attack.

Tilt the second is headed "Missing Links," and the onslaught begins upon Mr. Wallace, whose work on

"Darwinism" appears to have been published in the interval between the first and second essays. And here —perhaps not altogether disconnected with the appearance of Mr. Wallace's book—we find that the author has executed a series of mental evolutions with such skill that we have to rub our eyes in order to make sure that we have not deceived ourselves as to the position which he has actually taken. For natural selection, which, in the first essay, was considered to be so feeble as to be incapable of carrying on development through ten generations, even with the most favourable assumptions to start with, is now considered to be "as yet but hypothesis, and hypothesis which needs confirmation from fuller inquiry into the facts of the case, just as much as the other hypothesis of the continuity of forms between one species and another." At any rate, we seem to be justified in concluding from this that, as a scientific hypothesis, natural selection ranks with evolution, which, we were told in the first essay, had a right to be so called. The change of front has been very skilfully made, but that there has been a change is evident from the foregoing extracts.

The way in which evidence, which has been hitherto considered as fairly good from the evolutionist's point of view, can be manipulated so as to bear the quite opposite interpretation, is a study in intellectual jugglery which might be worthy of serious attention by certain classes of politicians. The second essay furnishes several examples of such feats. More especially may attention be called to the remarkable way in which the palæontological evidence is thus disposed of, and still more remarkable is the author's Podsnappian dismissal of the embryological evidence. Wallace's later treatment of natural variation is accepted :—

"The variations of form and structure which occur among wild animals—and the same is to be said for plants—are not occasional and minute, but incessant and important. There is clearly an end of the objection . . . based on the supposed infinitesimal character of variations."

But if the reader fondly imagines that this admission brings the author any nearer to Darwinism he will be grievously mistaken. For in this larger and more widely divergent variability Father Gerard sees a "centrifugal tendency" by which "every varying climate and soil and circumstance on the face of the globe should make its own species; or rather there should be no species at all, but a fleeting and evanescent succession of individual forms, like the shapes of clouds in a windy sky." Of course, evidence has to be adduced in disproof of this astonishing result, to which the later study of variability has led us, or rather should have led us. But there is no difficulty at all about this: the house sparrow and the water-crowfoot, we are told, are widely distributed over the face of the globe, and yet retain their specific forms and characters. True; but the instances of cosmopolitan species retaining their distinctness are few and exceptional; we are not told anything about local forms and races, or about "representative species"; we hear nothing about widely distributed species which merge imperceptibly into each other to the utter confusion of those who make species their particular study. Can it be that these facts are inconvenient and "not to be endured"? or has the author discovered some absolute criterion of species? If the latter is the case, he can hardly be congratulated on his definition :—

"It would seem to be simpler and plainer to say that a species is a *permanent group* [italics mine] of plants or animals framed in all particulars after a single type."

Enough has been said about this work to indicate its general tendency: its tone, on the whole, is antagonistic to evolution, but with respect to the special Darwinian form of this theory antagonism but feebly expresses the author's attitude. In each essay, the attack generally centres upon one or two representative writers; *e.g.* the third essay ("The Game of Speculation") dealing with Mr. Wallace, the fourth ("The Empire of Man") with Prof. Huxley, the fifth ("The New Genesis") with Messrs. Grant Allen and Edward Clodd, and the sixth ("The Voices of Babel") with a number of miscellaneous authorities, such as Mr. Herbert Spencer, Mr. Frederic Harrison, the late Prof. W. K. Clifford, and Sir James Stephen, of whom the author makes horrid examples by the very simple expedient of pitting their opinions against each other. From this general view, it will be seen that, so far as science is concerned, the effect of Father Gerard's last production will be practically *nil*. Among certain classes of general readers it may be mischievous, but we do not imagine that the mischief will spread very far. As the criticisms are for the most part destructive, it is impossible to attempt to deal with them in detail in these columns. Where it is possible to glean a vestige of a constructive idea, it will be seen that the main point towards which the author appears to be driving is that the doctrine of evolution—especially in its Darwinian form—is destructive of the notion of preconceived and determinate "plan," *e.g.* :—

"Intrinsic forces working definitely towards one plav not indeterminate forces swept hither and thither by external agencies like a cloud of dust, are suggested by the phenomena of nature."

We have become so accustomed to this style of criticism from all kinds of anti-evolutionary writers that it is almost superfluous to attempt to deal with it again. But it may really be asked whether those who are so constantly dinning this idea of a "plan" in nature will now condescend to give us some idea what that plan is. If "intrinsic forces are working definitely towards one plan," surely the author to whom has been permitted this glimpse into the inner sanctuary might enlighten the outer darkness a little by telling us something about the general scheme, or, at any rate, by giving us a notion as to the method by which he has arrived at such an important conclusion. On the other hand, if the author is satisfied that there is such a pre-arranged plan—whether he reveals that plan to the uninitiated or not—I, for one, fail to see how evolution, Darwinian or otherwise, has anything to do with the matter. If Father Gerard has managed to extract from the writings of popular authors, this notion of antagonism between ideas which are not necessarily antagonistic, with these authors must rest the responsibility. It cannot be said that the castigation which he has inflicted is altogether unmerited; there has been a great deal of crude and hasty speculation perpetrated in the name of evolution, and the blows aimed do

occasionally tell in the right direction. Had Father Gerard not sacrificed his position by aiming so much at smart writing—had he favoured us with more solid thought instead of endeavouring "to split the ears of the groundlings"—his lucubrations would have received more respectful attention. But satire and cynicism, interspersed with ridicule, are not the best methods for securing consideration from men of science, and it is surprising that the author should have resorted so largely to their use.

R. MELDOLA.

THE LAWS OF FORCE AND MOTION.

The Laws of Force and Motion. By John Harris (Kuklos). (London: Wertheimer, Lea, and Co., 1890.)

IN his preface the author, very rightly, sounds a warning note against the arrogance of Conventional Science, in its tendency to become ultra-conservative, intolerant, and extremely dogmatic.

But Real Science will always welcome and encourage attack and contradiction, feeling sure that Truth will ultimately prevail in the consensus of the majority who have devoted themselves dispassionately to the consideration of the facts in dispute. "Transibunt multi et augebit Scientia."

We presume the author would not ask to be judged with more leniency than he has displayed for the opponents he has singled out; so we may say at once that, after careful winnowing, we have not secured those grains of fact and truth which we were led to expect.

The experimental apparatus described seems carefully constructed and suitable for exact measurements; but does not differ essentially from that employed by Smeaton more than 100 years ago. However, the author assumes the true scientific sceptical spirit, in refusing to accept implicitly the statement of theoretical laws without putting them to the test of practical experimental verification.

Mathematicians will understand the nature of the author's attacks on Conventional Science from the specimen on p. 31:—

"It would seem that, some time ago, a highly influential party of natural philosophers (Leibnitz, the two Bernoullis, &c.) entertained and supported the idea that the momentum of a moving body varies as the square of the velocity. This idea or conclusion was probably based on an inference, that, since a double velocity of the resistance required four times the force to produce it, four times the momentum must have been imparted to the resistance."

After this wavering as to the meaning of momentum, we are quite prepared to find (p. 60) that the author is of the school who declare that the moon does not rotate.

The author cannot decide between 16·1 or 32·2 for the value of g (p. 24); and cannot settle in consequence whether the normal acceleration in a circle is the squared velocity divided by the radius or by the diameter (p. 19).

"Tangential force" is, in the author's opinion, a more correct scientific term to use than "centrifugal force," although he allows that the latter is hallowed by long usage; but in his treatment he enunciates a theorem on p. 21, "The actual lineal ratio of the sine to the arc, when the arc is an octant, is 9 to 10," quoted from his own "Treatise on the Circle and Straight Line"; this makes $\pi = 2\sqrt{2} \div 0·9$, a result worth recording by collectors of mathematical curiosities.

We hoped to find something combative in the articles on the Tidal Effect of Lunar Gravitation (p. 57), and on the Moon's Gravitative Influence at the Equatorial Surface of the Earth measured by Pendulum Oscillations (p. 76), considering that even the great Abel went astray in his theory at this point; but our author confines himself to vague generalities.

He would perform a valuable service to Science if he employed his experimental skill in observing the effect of Lunar Gravity on the Seconds Pendulum, as Conventional Science asserts that this effect does not amount to more than a rate of one 200th of a second in the day, although so noticeable in the Tides.

"Some Propositions in Geometry," by the same author, is advertised at the end of the book, whereof the Trisection of the Angle, the Duplication of the Cube, and the Quadrature and Rectification of the Circle, occupy the chief part; but we wonder whether the author has quite settled in his Geometry that the versed sine (or vertical height) is proportional to the chord, in a circle (p. 71). This might have been a misprint, but that the author adds immediately a numerical illustration, by saying that, if the chord is duplicated, the versed sine is also duplicated.

And this homely mode of verifying a law of comparison, by halving or doubling some quantity, and then observing the consequent change in the phenomena, is the single idea we consider worth lifting from the book, for general purposes of convincing argument and illustration of a mathematical law.

A. G. G.

OUR BOOK SHELF.

An Introduction to the Mathematical Theory of Electricity and Magnetism. By W. T. A. Emtage, M.A. (Oxford: Clarendon Press, 1891.)

THE want of a text-book especially designed for the use of candidates for examinations in which a knowledge of the more elementary portions of the mathematical theory of electricity and magnetism is demanded has been felt for some time. Though the absence of such a book has caused some inconvenience, we are not at all sure that it has been detrimental to the study of electricity, for hitherto the candidate for a mathematical examination in electricity has been compelled to learn the subject from books such as those of Maxwell, or of Mascart and Joubert, in which electricity is treated as what it really is outside the examination-room—a subject in which mathematics and experiment are closely mixed and mutually helpful: it is to this that, we think, is to be ascribed a good deal of that interest which electricity, above all other subjects, seems to excite in its students. When, however, the analytical parts of the subject are divorced from the experimental, we do not believe they will be found to excite any special enthusiasm, or that the result will be much more interesting than an ordinary text-book for the Mathematical Tripos on, say, hydrostatics.

There is no doubt, however, that there is a demand for a text-book suitable for examination purposes, and this demand will, we think, be well met by the book before us. The scope of the work may be described by saying that it includes nearly all the analytical parts of Maxwell's larger treatise which do not involve analysis higher than the simpler parts of the differential and integral calculus;

it thus covers the portions of electricity and magnetism which, under the new regulations, are selected for examination in Part I. of the Mathematical Tripos, and we have no doubt it will be found useful for that examination. The book is very well arranged, and the explanations are generally clear and concise. Among some minor points which, we think, might with advantage be altered in subsequent editions are the following. When discussing the rapidly alternating currents produced by discharging a Leyden jar, the author says: "We do not know, for instance, whether we are right in supposing the currents to be the same throughout the conducting wire." This seems an unnecessary affectation of ignorance, for we do know that such a supposition is certainly wrong. The method of determining "v" by repeatedly charging and discharging a condenser placed on one arm of a Wheatstone's bridge is not given, though several other less accurate methods are described. This is the more singular as the method itself is given in another part of the book as one for determining the capacity of a condenser, but no hint is given of its most important application. The method of measuring the self-induction of a coil, which is ascribed to Lord Rayleigh, is really due to Maxwell, and, though not in the treatise on "Electricity and Magnetism," is given in the paper on the "Dynamical Theory of the Electro-magnetic Field."

Le Sommeil et le Système Nerveux: Physiologie de la Veille et du Sommeil. Par S. Serguéyeff. (Paris: Felix Alcan, 1890.)

IT is difficult to understand why a writer upon the higher branches or outlying districts of neurology should assume that his readers are totally ignorant of the rudiments of that science, and should occupy nine-tenths of his book with a description of the anatomy and physiology of the nervous system. If, indeed, for the purpose of throwing new light upon his subject, he presented his facts in a new form, or taught them from a novel point of view, or arranged them so as to bring out some new principle, then there might be an excuse for restating the facts; but even then a brief summary would be enough for the purpose. there would be no need for the rediscussion of settled theories and the requotation of trite authorities. Scarcely ever do we find a writer on neurology who is content to assume that his readers are acquainted with the alphabet of his subject, or who will refrain from inflicting upon them the wearisome account of cells and fibres, of corona and cortex, illustrated by the familiar engravings that have done duty in so many previous books. The vicious habit is common enough and bad enough, but very rarely is it carried to such an extent as in the book before us, in which only about three hundred out of the seventeen hundred pages of which it is composed are devoted to the subject of which it is said to treat; the great bulk of the book being occupied by anatomical and physiological descriptions which are not in this case even relieved by illustration. So far is this system of padding carried, that the author has even inserted, in his book on waking and sleeping, descriptions of the minute structure of the retina, of the internal ear and the organ of Corti. When we have at last waded through his pages of preliminary matter, we do not find that he presents any fresh theory of sleep that is worth considering, or that he has any new facts to bring under our notice. It is a shame that a student should be trapped by an enticing title into spending his time in reading such stuff.

Elementary Science Lessons. By W. Hewitt, B.Sc. (London: Longmans, Green, and Co., 1891.)

THE thirty-six object-lessons contained in the present volume form the third part of a scheme of lessons drawn up by the author at the request of the Liverpool School Board. They are designed for children of Standard III., and are in continuation of others given in previously published volumes suitable for Standards I. and II. The author's long experience in teaching science to children in elementary schools gives him the ability which is necessary properly to draw up such a course as the one before us. For the most part the facts and principles dealt with relate to the classification of bodies into solids, liquids, and gases, and with the changes from one of these states to another. The experiments described may be performed with the simplest of apparatus, and the inferences to be drawn from them must be manifest to all children for whom the work is intended. Whenever possible, the principles considered in the lessons are applied to explain physiographical phenomena, thus aiding the development of that intelligent observation which is the soul of science. The arrangement of the matter is generally good, and elementary school teachers will find in the work exactly what they require for their pupils.

Solutions of the Examples in Charles Smith's "Elementary Algebra." By A. G. Cracknell. (London: Macmillan and Co., 1891.)

MR. SMITH'S small "Algebra" has deservedly obtained high favour in our schools for its lucidity. The work before us aims at presenting the solutions, not always necessarily in the shortest way, but rightly so as to "follow naturally from the formulæ and theorems with which the student is acquainted at that stage." It has Mr. Smith's *imprimatur*, for he has revised the sheets; and from our own examination of it we can commend it to teachers and students.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Anatomy of Heloderma.

THE number of NATURE for July 30, which I have only just seen, contains (p. 295) a criticism of a statement of mine, to which I have to answer. It is stated in my paper on the osteology of Heloderma that there are eight or nine premaxillary teeth in *H. horridum*, and only six in *H. suspectum*, because such is the number in the specimens examined by me. As Dr. Shufeldt has, on re-examination, found eight teeth in a specimen of the latter species, I admit that the distinction, as a specific character, does not hold good. It is just because my figures are *not* diagrammatic that they represent fewer teeth than are mentioned in the text; to anyone familiar with the dentition of lizards and snakes, it is clear enough that some of the teeth have been lost, and they were therefore not represented in the figures, which are faithful representations (in outline) of the objects from which they are drawn. I am much surprised at Dr. Shufeldt's statement, that he "cannot conceive of any lizard normally having but nine teeth in its premaxillary bone; it should at least be an even number." I could refer him to no end of examples of premaxillary teeth normally in odd number among lizards with single premaxillary; perhaps the best known is afforded by the family *Amphisbænidæ*. I must again correct Dr. Shufeldt on a matter of fact: my figure of *H. horridum* shows *seven* teeth, not *six*, as he states in his letter; and that of *H. suspectum five*, not *four*.

G. A. BOULENGER.

British Museum (Nat. Hist.), August 28.

A Straight Hand.

ALTHOUGH my writing master, who was an Englishman, taught me slanting letters which old habit still clings to, I approve highly what you say against it (NATURE, August 6, p. 325). Allow me to add some remarks on another side of that question. For many years past I have had in succession several amanuenses, and my first care has always been to require a straight hand without any distinction between up and down

strokes. These precepts and a few minor ones have been easily followed in all cases. I inclose a few lines copied from your interesting journal by a youth who does not understand English: he would have done this work with more care had he known that I wanted merely a sample. At all events it is most easy to read.

Straight letters without hair lines give the reader a comfortable facility which is a far greater compliment to a correspondent than the "*dear* Sir" imported from England to France during the last fifty years. We suppose that slant writing has been invented on your side of the Channel, and we call it therefore *écriture anglaise.* However, experience seems to show that it is more easily deformed than a straight one, and that it degenerates often into an illegible scrawl, causing much loss of time, or even, what is worse, a tiresome amount of perplexity and worry. We are told that the schoolmaster is abroad, but I am afraid that he leads our children on a false trail far away from the main aim of writing, which is *legibility.* Is the invention of type-writers the antidote or the outcome of illegible slants? Some of your philosophers may answer this question while giving a wholesome lesson to the schoolmaster.

A. D'ABBADIE (de l'Institut).

Abbadia, Hendaye, France, August 16.

Cordylophora lacustris.

IN NATURE for June 4 (p. 106) Mr. John Bidgood recorded the presence of this Hydrozoon in vast numbers on submerged roots and stems in the Ant, Bure, and Thurne. Till then its only known Norfolk locality was that given in Allman—"an agricultural drain near Lynn Regis." This summer innumerable colonies were to be seen on weed floating on the surface on both sides of the Thurne from Ludham Bridge right up to Hickling Broad. A boatman told me he had seen "them insecs" every summer for many years past. Mr. Edward Corder, the Secretary of the Norwich Natural History Society, took some early in June, and some, which he was good enough to send me, is still living in a 4-ounce bottle. All the authorities state that Cordylophora is a "light-shunning animal," and the localities hitherto recorded certainly warranted such a conclusion. But the colonies taken from the surface of the water by Mr. Corder, and those I took some time later, were stronger and cleaner than those obtained from below the surface. I distributed some of the gathering which I brought back to London, and learn that it is all doing well in ordinary aquaria. Some that I sent to Mr. Bolton for distribution unfortunately died in transit. One large colony, some eight inches long, on the stem of a Potamogeton, was kept in the shade for a fortnight; the tubes became flaccid, and the hydranths pendent, but they revived within twenty-four hours when exposed on the ledge of a window with a western aspect. This seems to point to a change of habit. All the colonies were doubtless founded below the surface of the water, and the weeds, when cut to clear the fairway for wherries, were floated up towards Hickling Broad by the tide. But if reproduction takes place—as it certainly does—under these conditions, is it not probable that we shall have a race tolerant of direct light, if not as sensitive thereto as *Hydra vulgaris?*

HENRY SCHERREN.

5 Osborne Road, Stroud Green, N., September 3.

Absolute and Gravitation Systems.

THE present condition of things is such that students of engineering need familiarity with, and ability to use, both systems o measuring force and related quantities. It seems necessary, therefore, that the transition from one system to the other should be kept clear of complications, and be presented as the simple matter which it really is. But in two text-books which have come to my notice, each offering points of excellence, and both evidently written by competent hands, a change in the unit of *mass* occurs in passing from the absolute to the gravitation system. The unit-mass is defined as the mass in which unit-acceleration is produced by unit force, which, of course, gives about 32 pounds as the mass-unit for the British gravitation system.

There is, in my opinion, much that is undesirable about this method of statement; the new mass-unit appears quite artificially in this one only of the many uses of the conception of mass, for the purpose, I suppose, of making it possible to put in generally applicable form such statements as: "Force is measured by change per second in momentum." My particular objection to it, however is that it locates the point of divergence among the fundamental units instead of among those derived from them. Does it not seem preferable to begin with units of mass, length, and time; to construct derived units, and to make common use of these as far as possible, postponing the differentiation of the two systems till the moment when it actually occurs? Surely it has been pointed out often, since the days of early exposition of these matters by Maxwell, Tait, and others, that the *force-unit* is the first cardinal point of difference, and that the absolute system simplifies here, while the gravitation system adopts another convention, which may be called arbitrary as opposed to the simpler one fixed upon by its rival.

In the hope of hastening the day of agreement in presenting the connection of ideas which underlie so much of modern physics and its applications, I have thought it permissible to state in summary, and for British units, the scheme used in my own teaching of mechanics. The claim is not advanced that the numerical work becomes different; indeed, the appended table is equally valid whichever basis be chosen; but there does seem to be a gain in logical clearness, as well as in what we may call historical accuracy.

Absolute System.—Fundamental units: foot, pound, second. Units of force, work, impulse derived in the usual way, so as to make proportional factors unity.

Gravitation System.—Fundamental units as before. Unit of force, the weight of one pound under circumstances specified to the required degree for scientific definiteness (locality, vacuum). Units of work and impulse connected with the force-unit, so as to make proportional factors unity.

The table shows the matter at a glance. g_1 is the value of g for the standard circumstances, and is to be regarded as a divisor in each case affecting the *product* of the other factors. The other symbols explain themselves.

Absolute.

$$P = mp,$$

$$\text{(work)} \int P\,ds = \text{(change in)}\,\frac{mv^2}{2},$$

$$\text{(impulse)} \int P\,dt = \text{(change in)}\,mv.$$

Gravitation.

$$P = \frac{mp}{g_1},$$

$$\text{(work)} \int P\,ds = \text{(change in)}\,\frac{mv^2}{2g_1},$$

$$\text{(impulse)} \int P\,dt = \text{(change in)}\,\frac{mv}{g_1}.$$

The choice of force-unit here affects what is logically subsequent to it, as it must; but leaves unaffected what is logically antecedent, as it ought.

So small a change as that of regarding g_1 as a divisor of m alone changes the basis of presentation; but there is an important difference of thought involved.

FREDERICK SLATE.

University of California.

Eucalyptus as a Disinfectant.

IN a paragraph on the use of Eucalyptus branches for disinfection, as recommended by Baron von Mueller, you have unintentionally stated that to be the manner in which I have used Eucalyptus.

For the last two years I have used "Tucker's Eucalyptus Disinfectant" (a solution of antiseptics in the essential oil) in all cases of scarlet fever and diphtheria, and have not had one case of infection. In the former disease I have not used any isolation, and in most cases have not excluded the other children of the family from the sick-room. None of the cases, except two or three that were severe, were kept to their bed-room more than ten days; the isolation of six or eight weeks being unnecessary, as the cuticle is perfectly disinfected. This is accomplished by rubbing the disinfectant over the whole body twice and then once a day for ten days.

Baron von Mueller, in a letter I received from him, quite approves of my method of disinfecting by inunction. I read a

paper before the Epidemiological Society last year on the subject. It is published in the Society's Transactions, and in a separate form by Mr. Lewis, of Gower Street. I also read a paper before the International Congress of Hygiene on antiseptic inunction. In this I have related the experience of other medical men in confirmation of my own. One, whose child had scarlet fever, placed his two other children in the same room, and kept them there for eight days, and they did not take the disease. This will be published in the Transactions of the Congress, and any one interested in the disinfection of infectious diseases, may obtain all the information they require from those two papers. J. BRENDON CURGENVEN.

Teddington Hall, S.W., August 17.

Alum Solution.

ONE frequently reads, in accounts of experiments on the physical or chemical action of luminous rays, that a *solution of alum* has been used to absorb obscure heat radiations. An instance of this occurs in your description of the investigation by M. D'Arsonval (NATURE, vol. xliv. p. 390). I should like to be informed if this practice is based upon actual evidence, or merely upon the supposition that, because alum itself cuts off a larger proportion of heat rays than any other easily available solid, its solution should be more effective than any other liquid. The only figures bearing on the question with which I am acquainted are those of Melloni, and he, as cited by Ganot, states the percentage of heat rays transmitted by alum solution as 12, and that by distilled water as 11. Why, then, not use distilled water? HARRY NAPIER DRAPER.

Dublin, August 27.

A NEW KEYED MUSICAL INSTRUMENT FOR JUST INTONATION.

ONE of those subjects which periodically turn up for discussion, and then vanish for an interval of neglect, is the possibility of obtaining just intonation in the performance of music. Those who have studied theory, properly so-called, know very well that the series of musical sounds commonly used, as expressed on the pianoforte, do not give the true harmonic combinations on which the art is based, and many zealous attempts have been made to cure the evil. One of these, showing some novelty and much merit, is now exciting the attention of eminent musicians on the Continent; it was mentioned briefly in NATURE of April 2 last (p. 521), and it may be interesting to many readers to give some further account of its general features. We may, however, preface this with a few words on the state of the question generally.

Although the equal division of the octave has now taken such a firm hold on modern musicians, it is only within a comparatively recent period that its use has become common. It was well known at an early date, but its defects checked its use until the general introduction of the class of instruments which have culminated in the pianoforte; the reason of its adoption then being that the want of sustaining power in the clavecin and the harpsichord so diminished the discordant effect as to make the faulty tuning endurable. People then began to get accustomed to it, and it was soon found that the system gave such extraordinary facilities for chromatic music, that the cultivation of this style became enormously developed. Hence the chromatic style and the equal temperament have become closely allied, and it is almost a matter of doctrine that the pianoforte division of the octave is a necessary element for the proper performance, or proper understanding, of the compositions of modern days.

For organs, the application of the equal temperament came much later. Down to about the middle of this century they were tuned on a system which gave the most usual keys fairly in tune, at the cost of an occasional harsh chord, which, for church purposes, was considered but a small price to pay for the general smooth and harmonious effect. But when highly skilled players began to increase, they required the organ to be more used for exhibition, and for this purpose the introduction of the equal temperament was deemed desirable. And so, as it thus commanded the two most powerful sources of music, it crept into use also by stringed instruments, orchestras, and voices, and so it has become general.

The consequence is that, now, practical musicians are in the habit of accepting the equal-tempered intonation as genuine and true music; and as the study of the principles of musical structure is by no means highly encouraged in this country, efforts are seldom made to undeceive them. Students are authoritatively told that questions about just intonation may be interesting to physicists and mathematicians as recondite problems in acoustical science, but that they have no bearing on "practical" music, and that, therefore, musicians need not trouble themselves about them. Some years ago, at a meeting of one of our musical educational establishments, it was said, "We do not here make music an affair of vibrations"—a sentiment which was received with loud applause.

No doubt some enthusiasts have carried the investigations on this subject to a degree of refinement which far outruns practical utility; and one can have little sympathy with those who delight in reviling and despising the duodecimal scale; seeing that it has been the means of materially advancing the art, and that the modern enharmonic system, founded upon it, has been so thoroughly incorporated into modern music that it is difficult to see how it could be now ignored.

But, on the other hand, one must, if one is to exercise reason and common-sense in musical matters, be equally at variance with the party who, arrogating to themselves the title of "practical" musicians, force on us the equal temperament to an extent which really means the extinction of true intonation altogether. We now, indeed, never hear it, and in fact only know by imagination what a true "common chord" means.

The principal objection to this state of things is that the ears of musicians become permanently vitiated, and lose the sense of accurate intonation, or the *desire to approach it*, which is tantamount to abandoning the most precious feature that modern music possesses—namely, beauty of harmony. A chord of well selected sounds, exactly in tune, is a very charming thing; but it is a thing unknown to ears of the present day. I can recollect the time when singers and violin-players strove to sing and play in good tune, and the effect of such unaccompanied part-singing, and such violin-playing, was very delightful. But now, music not being made "an affair of vibrations," one is often ashamed of the quality of what one hears; nobody seems to think purity of harmony, either with voices or violins or orchestras, to be a matter worth striving after.

It is surely a reasonable wish that this should be checked, but one must be reasonable in one's expectations. The pianoforte must certainly be let alone, and so must the organ when used for exhibitional purposes, though its cacophony under the present tuning detracts much from the pleasure of hearing such fine playing as is now common. But vocalists and violin-players ought to be encouraged, as of old, to sing and play in tune, and for this purpose what is wanted is an instrument which will keep up and circulate the tradition of what true music means. To attain this, therefore—*i.e.* to construct an instrument which shall enable a player, with moderate ease, to play polyphonic music, of moderately chromatic character, in strict tune—has been the aim of many ingenious musicians and mechanics.

I need not go into history. Everybody may see at South Kensington the wonderful enharmonic organ, built half a century ago by General Thompson, and may read of

the instruments described by Helmholtz, and his voluminous commentator, the late Dr. Ellis; and the efforts in the same direction of Mr. Colin Brown, and of Mr. Bosanquet, who has devoted much attention to the matter, are worthy of all praise. But my object now is to describe the latest attempt of the kind, by a native of Japan, Dr. Shohé Tanaka. Persons who have lately had to do with that country have been well aware, not only of the natural ingenuity of the Japanese, but of the high standing which many of their youth have taken in scientific studies. Dr. Tanaka combines these two qualifications. After an industrious preliminary education in his own country, he went to Berlin, where he has been for five years studying physical and mechanical science under the best professors, and with these he has combined also a study of music. He has published, in the *Vierteljahrsschrift für Musikwissenschaft* for 1890, a long essay on the subject generally, which fully demonstrates his knowledge of it; and he appears to have made a very favourable impression in Germany. He exhibited his "Enharmonium," as it was called, to the Emperor and Empress, and he produces testimonials from many musicians of the highest rank, among whom are Joachim, Von Bülow, Reinecke, Richter, Fuchs, Moszkowski, the whole staff of the Leipzig Conservatoire of Music, and many others. These not only speak highly of the instrument, but (in strong contrast to the English authorities) earnestly support and recommend the object it is proposed to serve. Indeed, some of the testimonials are essays on the advantage of the cultivation of pure intonation. Von Bülow especially says:—

"I have requested the maker to make me such an enharmonium for my personal use at home. I am earnestly desirous to protect myself during the few remaining years of the exercise of my art against constantly possible relapses into already conquered errors. In order to make pure music it is necessary to think in pure tones. It is *de facto* the practically insuppressible conventional pianoforte-lie to which nearly all corruptions of hearing may be traced."

With these credentials the inventor has brought a sample of his instrument for examination in England, and I may proceed to give some idea of what it is like.

The great object to be aimed at is facility of performance. It is in this respect that most of the former instruments have failed; the multitude of notes has generally required a new kind of clavier, or the manner of manipulating them has been so complicated and difficult as to require a special learning attended with much trouble. The present instrument is a harmonium of five octaves, having a key-board modelled precisely on the usual pattern and size. Dr. Tanaka has greatly simplified the problem by adopting the transposing system, often adopted with pianofortes. Whatever key the music is in, it is played in the simplest of all keys, the key of C, and by means of a bodily shifting of the key-board to the right or left, it is set so as to act in the key required. It is, in fact, the principle used in the horn tribe; the horn or trumpet player reads and plays his music in the key of C, and the transposition of this to the key required is previously arranged as a part of the mechanism of the instrument; or, rather, as the author puts it, the music may be read and played on the tonic sol-fa system, and he might have adopted its symbols if he had not feared it would be too startling a change.

The points in which the new key-board differs from the ordinary one are, that the black keys are divided, some into two and some into three parts, and one additional shorter and narrower black key is introduced between the E and F white keys. This arrangement gives twenty notes, which suffice for modulating into a reasonable number of keys with sharp signatures.

To provide for modulations into keys with flat signatures, since these and the sharp modulations are not both wanted at the same time, six of the notes can be instantaneously changed for the purpose, at any time, in a manner hereafter explained.

The whole of the keys are well under the hand, and, if the performer knows which note he ought to use, he can take it in any usual chord without difficulty.

Fig. 1 represents one octave of the key-board as arranged for the key of C, with provision for modulating into keys with sharps.

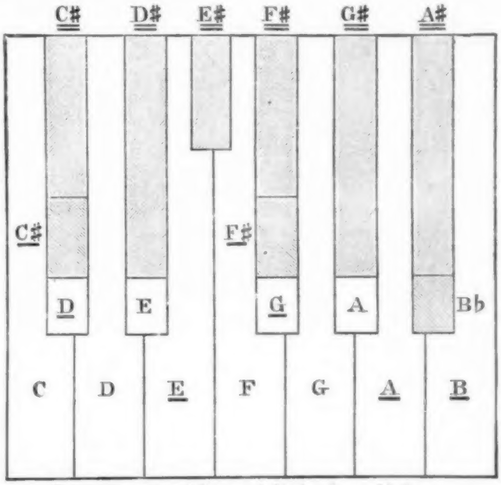

Fig. 1.—As arranged for modulation into keys with sharps.

In order to explain the exact intonation or musical position of the notes, the author adopts a notation already pretty well known—namely, when the letter indicating a note has no line above or below it, it is intended to correspond with what may be called the "Pythagorean" position of that note, which is given by a succession of fifths upwards from C as a base. If the letter has a stroke below it—thus, $\underline{E}$—it is a comma below that position; and if the stroke is above—thus, $\overline{E\flat}$—it is a comma above that position. Two strokes below—thus, $\underline{\underline{C\sharp}}$—indicate two commas below.

Now, in the first place it will be seen that the ordinary seven white keys indicate the seven ordinary notes of the major scale of C, according to the intonation usually understood, *i.e.* the major triads on the tonic, dominant, and subdominant, being perfectly in tune.

But as, for certain harmonies, variations of some of these notes are required, there are four alternative small white notes, D, E, G, and A, placed at the near extremity of four of the black ones. For example, the note D is the one required to make the true minor third

, or the true fifth .

The position of the keys for the sharp notes, and also their intonations, will be seen in the figure. F♯ and C♯ each require alternative values, a comma distant from each other, and these are obtained by dividing the black keys in the manner formerly practised with some organs in this country.

It will be seen that there are in all twenty effective finger keys, each sounding a separate note.

When it is requisite to modulate into keys with flats, the above arrangement will not answer; and the necessary change is made by a lever placed conveniently for being worked by the knee of the player, like the swell of a harmonium.

When this is pushed over, the six hindmost black keys are altered from sharps to flats, as shown in Fig. 2. $\underline{C}\sharp$ and $\underline{F}\sharp$ still remain, and an alternative B♭ and an alternative F are added. This change gives six new notes, so that the total number of sounds used in the octave, for the key of C with its modulations, is twenty-six.

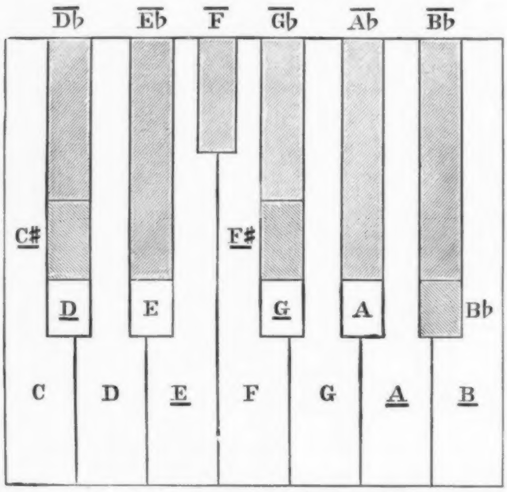

FIG. 2.—As altered for modulation into keys with flats.

As a further indication of the exact musical positions of these twenty-six notes, their ratios of vibration with the keynote C, may also be given. And the logarithms of these (here limited, for simplicity, to three places) will represent approximately the height of each note above C. In this scale, an octave is represented by 301, a mean semitone by 25, and a comma by 5.

Table of the Positions of the various Notes used for the Key of C.

	Ratio.	Logarithm.		Ratio.	Logarithm.
C	$= 1$	... 0			
D	$= \frac{9}{8}$	... 51	$\underline{D}$	$= \frac{10}{9}$	... 46
$\underline{E}$	$= \frac{5}{4}$	... 97	E	$= \frac{81}{64}$	... 102
F	$= \frac{4}{3}$	... 125	F	$= \frac{27}{20}$	... 130
G	$= \frac{3}{2}$	... 176	$\underline{G}$	$= \frac{40}{27}$	... 171
A	$= \frac{5}{3}$	.. 222	A	$= \frac{27}{16}$	... 227
B	$= \frac{15}{8}$	... 273			
$\underline{F}\sharp$	$= \frac{45}{32}$	... 148	$\underline{\underline{F}}\sharp$	$= \frac{25}{18}$	... 143
$\underline{C}\sharp$	$= \frac{135}{128}$	... 23	$\underline{C}\sharp$	$= \frac{25}{24}$	... 18
$\underline{G}\sharp$	$= \frac{25}{16}$	... 194			
$\underline{D}\sharp$	$= \frac{75}{64}$	... 69			
$\underline{A}\sharp$	$= \frac{225}{128}$	... 245			
E♯	$= \frac{675}{512}$	... 120			

	Ratio.	Logarithm.		Ratio.	Logarithm.
B♭	$= \frac{9}{5}$	... 255	B♭	$= \frac{16}{9}$	.. 250
$\overline{E}\flat$	$= \frac{6}{5}$	... 79			
$\overline{A}\flat$	$= \frac{8}{5}$	... 204			
$\overline{D}\flat$	$= \frac{16}{15}$	.. 28			
G♭	$= \frac{64}{45}$	.. 153			

This information will enable any student of musical theory to judge of the capability of the instrument to play modern music with just intonation. The great object is, of course, to play the consonant triads, major and minor, in strict tune, and it will be found that the instrument, as above arranged, will play the following

Major Triads on—

C, D, E, F, G, A, B,
F♯, B♭, E♭, A♭, D♭, G♭,

Minor Triads on—

C, D, E, F, G, A, B,
F♯, C♯, G♯, D♯, A♯, B♭,

and some of each in duplicate with a comma variation. These would certainly seem sufficient for all ordinary music in C major or A minor.

By means of the transposing movement, the key-board can be set upon either of the eleven other keys, for which a similar modulating power is obtained, except in some very remote cases. In order, however, to effect this, ten additional notes are used, making thirty-six in all. But the adaptation of them is entirely automatic, and the mechanism for this purpose constitutes one of the chief novelties of the invention.

This is the provision for the purpose by the manufacturer. Now, let us see what the *performer* has to do.

In the first place, whatever key the original composition is in, it must be played in the key of C. In these days of strict examinations by the College of Organists, it is not uncommon to find players who can transpose at first sight from any key into any other. For players who cannot do this the piece will have to be re-copied, but this is nothing in comparison with the great gain in simplicity of the key-board.

Secondly, the performer has not only to play the music in the ordinary way, but he has another problem before him—namely, where certain notes are in duplicate, he has to decide which of the two to use. Now this, although by no means a difficult matter, requires some knowledge of the theory of music, in a sense beyond what is ordinarily taught. To explain it would lead us into more technical detail than would be proper here; but Dr. Tanaka, in compassion for those unfortunates with whom music "has not been made an affair of vibrations," has shown that the printed music can have certain very simple symbols prefixed to the notes, which will easily guide the purely "practical" player what to do.

In this way any competent organist, though he may never have heard of the system before, may, after a few minutes' explanation, and a quarter of an hour's practice, play any piece of music correctly in the true musical intonation, a result which, I believe, has never been attained by any former instrument, and which says much for the ingenuity of the whole contrivance.

It is recorded that the Emperor of Germany expressed a wish to see the experiment tried on a large organ, and the inventor is now engaged in constructing one with eight stops, and a simplified enharmonic pedal-clavier, for the Prussian Goverment. WILLIAM POLE.

THE NEW AUSTRALIAN MARSUPIAL MOLE— NOTORYCTES TYPHLOPS.

OUR Corresponding Member, Prof. E. C. Stirling, of the University of Adelaide, has most kindly sent to us an original water-coloured drawing of the newly-discovered Australian Marsupial, prepared from a pencil sketch taken from life. The animal is represented upon the surface of one of the red sandhills in which it passes the greater part of its life, among some tussocks of *Ariodia irritans*, the "porcupine grass" of the interior of Australia, and is figured of the natural size. The drawing will be exhibited at the first scientific meeting of this Society in November next, but in the meanwhile can be inspected in our library by any naturalist who may wish to see it.

Prof. Stirling has also sent us a copy of his paper in the Transactions of the Royal Society of South Australia (read February 3 of the present year), in which this extraordinary animal is fully described. The subjoined particulars as to its habits, extracted from Dr. Stirling's article, will be interesting to the readers of NATURE:—

"It appears that the first specimen was captured by Mr. Wm. Coulthard, manager of the Frew River Station and other northern runs belonging to the Willowie Pastoral Company. Attracted by some peculiar tracks, on reaching his camp one evening on the Finke River, while traversing the Idracoura Station with cattle, he followed them up, and found the animal lying under a tussock of spinifex or porcupine grass (*Triodia irritans*). Though he is an old bush hand, with all the watchful alertness and powers of observation usually acquired by those who live lives of difficulty and danger, this was the first and only specimen of the animal he ever saw. As previously stated, this found its way to the Museum through the agency of Messrs. Benham and Molineux. The three subsequently received shortly afterwards, as well as the last lot recently secured by Mr. Bishop during our journey through the country, were also found on the Idracoura Station. This is a large cattle-run comprising several hundred square miles of country in the southern part of the Northern Territory of South Australia, which lies immediately to the west of the telegraph line between the Charlotte Waters and Alice Springs Stations. The great dry water-course of the Finke River, which runs from north-west to south-east, bounds the run for some eighty miles on the north and north-east. Its distance from Adelaide is, roughly speaking, a thousand miles. Flats and sandhills of red sand, more or less well covered with spinifex and acacias constitute a large portion of the country, and the rainfall is inconsiderable. Curiously enough, all the specimens of *Notoryctes* hitherto received by me have been found within a circumscribed area, four miles from the Idracoura Head Station, which is situated on the Finke watercourse itself, and almost invariably amongst the sandhills. I have it, however, on very fair authority, that the animal has been seen on the Undoolya Station, which lies immediately south of the McDonnell Ranges, and that one also was found drowned after heavy rain at Tempe Downs, a station situated about 120 miles west-south-west of Alice Springs. These points will sufficiently define its range, so far as is known at present. They do not appear to be very numerous. Very few of the white men in the district had ever seen it, even though constantly travelling; and not many of the natives whom I came across recognized the well-executed drawing I carried with me. It must be remembered, however, that I did not pass through the exact spot which so far appears to be its focus of distribution. Nor did a very considerable reward, which I offered, cause any specimens to be forthcoming between the first lot received, over two years ago, and that recently secured during my trans-continental trip. With a few exceptions, the animals have been captured by the aboriginals, who, with their phenomenal powers of tracking, follow up their traces until they are caught. For this reason they can only be found with certainty after rain, which sets the surface of the sand, and enables it to retain tracks that would immediately be obliterated when it is dry and loose. Nor are they found except during warm weather, so that the short period of semi-tropical summer rains appears to be the favourable period for their capture. For this suitable combination of wet and warmth, Mr. Bishop had to wait three months before he was able to get them, and in all cases they were found during the day-time. Perpetual burrowing seems to be the characteristic feature of its life. Both Mr. Bishop and Mr. Benham, who have seen the animal in its native state, report that, emerging from the sand, it travels on the surface for a few feet at a slowish pace, with a peculiar sinuous motion, the belly much flattened against the ground, while it rests on the outsides of its fore-paws, which are thus doubled in under it. It leaves behind it a peculiar sinuous triple track, the outer impressions, more or less interrupted, being caused by the feet, and the central continuous line by the tail, which seems to be pressed down in the rear. Constantly on the look-out for its tracks, I was often deceived by those of numerous lizards, which are somewhat similar in these respects.

"It enters the sand obliquely, and travels under ground either for a few feet or for many yards, not apparently reaching a depth of more than two or three inches, for whilst underground its progress can often be detected by a slight cracking or moving of the surface over its position. In penetrating the soil, free use as a borer is made of the conical snout with its horny protecting shield, and the powerful scoop-like claws (fore) are also early brought into play. As it disappears from sight, the hind-limbs, as well, are used to throw the sand backwards, which falls in again behind it as it goes, so that no permanent tunnel is left to mark its course. Again emerging, at some distance, it travels for a few feet upon the surface, and then descends as before. I could hear nothing of its making, or occupying at any time, permanent burrows. Both my informants laid great stress on the phenomenal rapidity with which it can burrow, as observed in both a state of nature and captivity."

To these notes of Prof. Stirling I may add the remark that this is certainly one of the most extraordinary discoveries in zoology made of late years. *Notoryctes typhlops*, as shown by Prof. Stirling's full and elaborate description and figures, is unquestionably a new and perfectly isolated form of Marsupial life, and must be referred to a new section of the order Marsupialia. We must all congratulate Prof. Stirling on his success in bringing before the world such an important novelty.

P. L. SCLATER.

Zoological Society of London, 3 Hanover Square, W., August 20.

FRANCIS BRÜNNOW, PH.D., F.R.A.S.

WE regret to have to announce the death of Francis Brünnow, whose fortune it was to earn in two continents a reputation as an ardent astronomer and an indefatigable observer and computer. He was not less distinguished as a Professor at Ann Arbor, Michigan, than when he filled the Chair of Astronomy at Dublin, and occupied the position there of Astronomer-Royal. He was fortunate in his early career. Nearly fifty years ago he was one of the band of earnest astronomers that Encke summoned round himself at Berlin, and thus he became the friend and companion of Galle, of Bremiker, and of D'Arrest. The time, too, was interesting. Adams and Leverrier had traced the existence of a Neptune, and the issue of that well-known drama was worked out

under the eyes of the late Dr. Brünnow. He was present in the Berlin Observatory when Neptune was first recognized as a planet, and an early, if not the earliest, notification of its discovery, that reached this country, came from his hand.

It would be tedious to recall all the results that his untiring industry wrought in the department of cometary astronomy. His greatest and best-known work is his classical investigation of the motion of De Vico's comet of short period. The close and eager search that was made for this comet, particularly in 1855, was not successful, and its ultimate career is unknown; but this fact does not detract from the merit of Dr. Brünnow's memoir, on which a lesser reputation might rest. As a calculator of a high order, he will, however, be remembered for his work on the theory of some of the minor planets, as Flora, Victoria, and Iris—a work which to some extent was carried out during his Directorship of the Observatory of Ann Arbor, Michigan, to which he was appointed in 1854. Here, too, he published for a short time a periodical under the title of *Astronomical Notices*. This journal had but a short life, and judging from its rarity must have had but a small circulation. A very different fate attended the publication of his "Lehrbuch der sphärischen Astronomie," first issued in 1851, and which has passed through several editions, been more than once translated, and is everywhere recognized as an authoritative text-book.

In 1865, on the death of Sir W. Hamilton, Dr. Brünnow was appointed Andrews Professor of Astronomy in the University of Dublin and Director of the Dunsink Observatory. The important and original mathematical researches in which his illustrious predecessor had been engaged had not left him sufficient leisure to superintend with activity the affairs of the Observatory; and the work of organizing and of placing it on a modern footing, adequately equipped, fell to the lot of Dr. Brünnow, who proved himself admirably fitted for the task. The South object-glass, which had remained unmounted, was, under Dr. Brünnow's auspices, provided with an equatorial movement, and with it he carried out the researches in stellar parallax which marked alike his assiduity and his competence as an observer. This line of research, thus connected with the Observatory, his successor, Sir Robert Ball, has recognized and pursued with vigour and success. In 1874, Dr. Brünnow retired from the Directorship on account of failing health and eyesight, and he has since lived privately, principally abroad. He died at Heidelberg, in his sixty-seventh year, to the deep regret, not only of his numerous private friends, but of all those who have profited by his teaching, whether as members of his class or students of his valuable contributions to astronomy.

NOTES.

THE Australasian Association for the Advancement of Science will hold its fourth annual meeting at Hobart in January 1892. The first general meeting will take place on January 7, when Sir James Hector will resign the chair, and Sir Robert G. C. Hamilton, Governor of Tasmania and President of the Tasmanian Royal Society, will assume the Presidency, and deliver an address. Visits to places of interest in the immediate neighbourhood of Hobart will be made during the time when the meeting is being held, and afterwards there will be excursions to different places in Tasmania. Application has been made to the New Zealand Shipping Company, and to Shaw, Savill, and Albion Company, for passages at reduced rates to members of the British Association visiting Tasmania to attend the meeting at Hobart, and it is expected that this will be granted.

THE International Electro-Technical Congress was opened at Frankfort-on-the-Main on Tuesday. An address was delivered by Dr. Stephan, Imperial Minister of Post and Telegraphs. Some 650 members, of whom 198 were foreigners, attended the proceedings. After the usual complimentary speeches, the following gentlemen were elected Presidents of the various Sections of the Congress:—Herr Siemens, of Berlin Mr. Preece, of London; M. Hospitalier, of Paris; Signor Ferrares, of Turin; Herr Waltenhofen, of Vienna; and Herr Kohlrausch, of Hanover. It was decided that a special Section should be formed to consider the principles of legislation dealing with electro-technical matters.

THE Crystal Palace Electrical Exhibition, to be opened on January 1 next, has received the sanction of the Board of Trade, and is duly certified as an International Exhibition, under the provisions of the Patents, Designs, and Trade Marks Act, 1883. The exhibits of Her Majesty's Government will include historical telegraphic and electrical apparatus, instruments, and appliances, as well as the modern apparatus and instruments now in use in the Postal Telegraph Department. This exhibit will be arranged under the direction of Mr. W. H. Preece, F.R.S.

IT has been suggested in America that steps should be taken to secure an International Conference of Electricians at the "Columbian World's Fair." "The time and place," says the new Chicago journal, *Electrician*, "are certainly auspicious, and as there are many questions in electrical science that are now awaiting adjudication it would seem that it were only necessary that the invitation be made by the properly constituted bodies to have it meet with the hearty approbation of scientific men everywhere. Could such a Convention be assembled it would do more than any other agency to bring together at the Columbian Exposition the most complete and varied display of electrical apparatus the world ever saw."

THE International Agricultural Congress was opened on Monday at the Hague by M. Méline, the President, who briefly reviewed the labours of the Paris Congress, dwelling upon its great importance to agriculture in general, and pointing out that the results obtained by that meeting would assist the various Governments in the legislative, administrative, and financial problems requiring solution. The conclusions arrived at in Paris were, however, not final, and would be more precisely defined by the present assembly.

WE have received an intimation of the sudden death, from apoplexy, of Dr. L. Just, Professor of Botany at the Polytechnikum, Carlsruhe, and Director of the Botanic Garden belonging to the same institution. Dr. Just was best known to the botanical world through the *Botanischer Jahresbericht*, which has appeared under his name since its foundation in 1874 up to the present time, though he resigned the editorship in 1885.

MR. CHARLES JAMRACH, well known as an importer, breeder, and exporter of all kinds of animals, died last Sunday at his residence in Bow. He was of German parentage, and inherited from his father the business which he conducted with so much energy and intelligence. Many scientific collections, as well as travelling menageries, have been enriched by him with valuable specimens. He showed particular interest in the breeding of long-coated Persian greyhounds, Japanese pugs, and Madagascar cats. The collection he had last formed includes, the *Times* says, young lions, tigers, and dwarf cattle from Burmah.

THE number of visitors to the South Kensington Museum during the last month exceeded 120,000. This is the largest number in any one month since 1883, in which year the Fisheries Exhibition was held opposite to the Museum, on the ground formerly occupied by the Royal Horticultural Society.

THE Staffordshire County Council have appointed Prof. D. E. Jones, B.Sc. (of the University College of Wales, Aberystwyth), as Director of Technical Instruction for Staffordshire.

THE Oxford Delegates responsible for the University Extension work have just published their Annual Report for the year ending July 31, 1891. No fewer than 192 courses of lectures were delivered. Of these, 90 were on historical subjects, 64 on natural science, 33 on literature and art, and 5 on political economy. These figures show a small increase in the number of courses on history and literature, and evidence a marked increase in the attention that is being paid throughout the country to natural science. On the other hand, political economy does not appear to be popular with those who are responsible for the arrangement of the lectures, and this circumstance the Delegates regret. At several centres in the North of England the courses have been regularly attended by many hundreds of artisans, and the funds to defray the expenses of these lectures have been provided by working men societies. The results of the examinations have in many cases been most satisfactory. In the opinion of Mr. York Powell "The paper classed as distinguished would have been accepted in Oxford as distinctly belonging to the honour class; the 'pass' standard is that which would be adopted in the Oxford pass school." Mr. Lodge and Mr. A. H. Johnson bear similar testimony to the efficiency and capacity of the students.

THE *Times* has been printing an interesting correspondence on county museums, and we may hope that the discussion will lead to some practical results. There can be no doubt as to the need for such institutions. Properly organized, they might be of high educational value, and they would preserve for posterity many objects of archæological interest which are now in danger of being either destroyed or lost. The aim of the proposed museums ought, however, as Prof. Flower has urged, to be very clearly defined, and it would be necessary that arrangements should be made for the preparation of good catalogues and labels.

EVERYONE interested in the scientific aspects of agriculture was sorry to hear that Miss Ormerod had felt it necessary to resign her position as consulting entomologist to the Royal Agricultural Society. It is much to be regretted that misunderstandings should have led to the severance of her connection with the Society with which she has so long been honourably associated. Fortunately her work as an entomologist is not to be interrupted, and she will continue to place her knowledge at the service of agriculturists.

THE Department of Agriculture in New South Wales is not likely to complain of lack of work. During the first three months of the Department's existence—March to May 1890—1200 letters were received from farmers and others on matters of agricultural interest; during the same months of this year, 2300 were received and fully answered. During the first five months of the current year, over 1000 letters were written by the Department, giving specific advice on manures, analysis of soils, insect pests, and parasitic diseases, and were gratefully acknowledged; 18,000 Gazettes and Bulletins were distributed, and 7000 circulars sent out.

IN the official statement relating to the work of the British Museum (Natural History) during 1890, reference is made to two new cases which have been placed in the central hall. One of them illustrates external variation according to age, sex, and season, as exemplified in the well-known bird the Ruff (*Machetes pugnax*). The other case is intended to illustrate the subject of protective resemblance and mimicry. The lower part of the case is occupied by a group showing the simplest form of such resemblance, *i.e.* general conformation of colour to habitual surroundings. Various species of mammals, birds, and reptiles, from the Egyptian desert, are arranged upon a ground consisting of the actual rocks and sand among which they were living. These specimens were collected in February 1890, and presented by Mr. F. S. Worthington. In the upper part of the case specimens are exhibited, chiefly from the class of insects in which the imitation both of the form and colour of external objects is carried to various degrees of perfection and complexity. Among these is a group of Indian butterflies (*Kallima inachis*), which, when at rest with their wings closed, present a marvellous resemblance to dead leaves. Still further stages of complexity of imitation are shown in insects which closely resemble, externally, others belonging to different families or even orders, apparently for purposes of protection.

M. E. HECKEL, of Marseilles, has recently described an interesting case of mimicry which may be frequently seen in the south of France. The mimic is a spider, *Thomisus onustus*, which is often found in the flowers of *Convolvulus arvensis*, where it hides itself for the purpose of snaring two Diptera, *Nomioides minutissimus* and *Melithreptus origani*, on which it feeds. Convolvulus is abundant, and three principal colour-variations are met with: there is a white form, a pink one with deep pink spots, and a light pink form with a slight greenishness on the external wall of the corolla. Each of these forms is particularly visited by one of three varieties of *Thomisus*. The variety which visits the greenish form has a green hue, and keeps on the greener part of the corolla; that which lives in the white form is white, with a faint blue cross on the abdomen, and some blue at the end of the legs; the variety which lives in the pink form is pink itself on the prominent parts of the abdomen and legs. If the animal happens to live on *Dahlia versicolor*, the pink turns to red, and if it lives in a yellow flower—*Antirrhinum majus*, for instance—it becomes yellow. At first Prof. Heckel supposed the three varieties of *Thomisus* to be permanent, but he discovered accidentally that any one of these peculiarly coloured spiders, when transferred to a differently coloured flower, assumes the hue of the latter in the course of a few days; and when the pink, white, green, and yellow varieties are confined together in a box, they all become nearly white.

MR. THEODORE BENT, according to a telegram received from him at Cape Town, has good reason to be satisfied with the results of his investigation of the Zimbabye ruins. He is of opinion that the "finds" unmistakably indicate the form of worship, the manner of decoration, and the system of gold smelting practised by the vanished people who inhabited the buildings. He is now visiting other ruins.

THE series of "One Man" photographic exhibitions at the Camera Club is to be continued during the coming winter. According to the Journal of the Club, there will first be an exhibition of photographs by Mr. Ralph W. Robinson. This will be followed by an exhibition of the work of Mr. J. P. Gibson, of Hexham.

AT a meeting of the Meteorological Society of Mauritius on July 30, it was stated that, on June 13 and 14 last, thunderstorms occurred in that island. This, so far as was known, was the first instance of a thunder-storm having taken place since the year 1801. There was a considerable increase of sunspots at about this time, and on June 14 a remarkable magnetic disturbance took place. Photographs of the latter part of the transit of Venus, on May 10 last, were exhibited. At sunrise the planet had already traversed about one-half of its apparent path, and its appearance was perfectly round and intensely black. The time of tangential contact (at egress) was, as nearly as could be ascertained, 8h. 36m. 36s. A number of charts

showing the winds and weather experienced by several vessels which encountered cyclones in December, January, and February last were submitted; the greatest of the disturbances which had been experienced of late occurred from February 3–13. At the Observatory the barometer fell from 29·962 inches, at 9h. a.m. on the 1st, to 29·409 inches, at 3h. 25m. a.m. on the 6th. Full details of these cyclones will be published. With reference to the "Atlas of Cyclone Tracks," lately published by the Meteorological Council, Dr. Meldrum stated that the preparation of an appendix was under consideration.

THE Report of the Meteorological Commission of Cape Colony for the year 1890 contains the results of observations taken at 45 principal stations, and monthly and yearly rainfall values at about 300 stations in the colony and neighbouring States. The observations are made chiefly by public officials, and by private gentlemen who lend their aid. Summaries from a selected number of rainfall stations are also published monthly in the *Government Gazette* and in the *Agricultural Journal*. The expenditure for the year was only £378, so that, considering the smallness of the funds available, the results obtained are highly satisfactory; and the cost of instruments, which become the property of the observers after 5 years' continuous observations, is not inconsiderable. The Commission express the hope that their labours may lead to the discovery of the laws which govern the weather in those parts, and ultimately result in the issuing of trustworthy storm warnings. With this view simultaneous observations from various stations are telegraphed to various ports, where they are entered on sketch maps for the information of mariners and others.

A CORRESPONDENT informs us that Dr. Sleich, of Berlin, has found that the subcutaneous injection of distilled water produces sufficient local anæsthesia at the point of insertion to allow small operations, such as opening a boil, to be made without pain.

THE following are some results of Herren Elster and Geitel's recent electric observations on the Sonnblick, described to the Vienna Academy:—The intensity of the most refrangible solar rays, measured by their discharging effect on a negatively electrified surface of amalgamated zinc is about doubled on rising 3100 m. from the lowland. The authors were unable to find other actino-electrically active substances; even pure fresh snow and dry Sonnblick rock were not perceptibly discharged by light. Waterfalls may produce in a valley a negative fall of potential, and to considerable heights (500 m.). The morning maximum in fall of potential, observed regularly between 7 and 9 a.m. in the plain and in Alpine valleys, was absent at 3100 m. Before thunderstorms in July, the positive fall of potential sank gradually, in light showers, to *nil*, at which it remained sometimes two or three hours till completion of the electrical process in the cloud. In thunder-clouds, or on low ground, during a thunderstorm, the atmospheric electricity usually changes sign after a discharge. St. Elmo's fire (negative as often as positive) always accompanied thunderstorms. The observation that negative St. Elmo's fire burns with blue flame, positive with red, was repeatedly confirmed.

IT is well known that the fox possesses an excellent "head for country." Referring to this subject in an interesting article in the current number of the *Zoologist*, Mr. Harting says a fox has been known to return seventy miles to his "earth," and this not once, but three times. He was caught in Yorkshire, and sent into Lancashire to be hunted by the hounds of the late Mr. Fitzherbert Brockholes, of Claughton Hall, Garstang, and his identity was established by his having been marked in the ear by the fox-catcher. This story Mr. Harting had from his friend Captain F. H. Salvin, who was living in Yorkshire at the time, and was well acquainted with Mr. Brockholes, who gave him all the details.

DURING the nesting season the male ostrich seems to be anything but an agreeable creature. In a paper lately read before the Royal Society of Tasmania, Mr. James Andrew says that at that period the bird is most pugnacious, and may only be approached in safety with great precaution. He resents the intrusion of any visitors on his domain, and proves a most formidable opponent. His mode of attack is by a series of kicks. The leg is thrown forwards and outwards, until the foot, armed with a most formidable nail, is high in the air; it is then brought down with terrific force, serious enough to the unhappy human being or animal struck with the flat of the foot, but much worse if the victim be caught and ripped by the toe. Instances are known of men being killed outright by a single kick, and Mr. Andrew remembers, whilst on a visit in the neighbourhood, that on a farm near Graaff Reinet a horse's back was broken by one such blow aimed at its rider. If attacked, a man should never seek safety in flight; a few yards and the bird is within striking distance, and the worst consequences may result. The alternative is to lie flat on the ground, and submit with as much resignation as possible to the inevitable and severe pummelling which it may be expected will be repeated at intervals until a means of escape presents itself, or the bird affords an opportunity of being caught by the neck, which, if tightly held and kept down, prevents much further mischief. Under such circumstances, however, Mr. Andrew has known a bird, with a badly-calculated kick, strike the back of its own head, scattering the brains—"a serious loss of valuable property to the farmer."

WE learn from the Tiflis paper *Caucasus* that during an excursion to the sources of the Jiagdon, which was made recently by several explorers, no fewer than eight glaciers were discovered, six of which are not marked on the 5 versts to the inch map of Caucasus. They have been viewed now and sketched from Styr-khokh Pass. The southern slope of the branch-ridge of the main chain, between the Kazbek and the Syrkhubarzon peak, has also been sketched from the Trussoff's Pass, and it appears that several of the glaciers of this part of the chain are not represented on the great map, while perpetual snow is shown where there is none. The glaciers visited by the party proved to have very much changed their aspect since 1882. Several sulphur and iron carbonate springs were visited in the Trussoff's valley, and several interesting Alpine flowers in bloom were collected on the passes.

A SKETCH of the vegetation of British Baluchistan, with descriptions of new species, published originally in the Linnean Society's Journal, has now been issued separately. The author is Mr. I. H. Lace, who has had the advantage of Mr. W. B. Hemsley's aid.

IN the *Bulletins de la Société d'Anthropologie de Paris* (fourth series, vol. ii. Parts 1 and 2) the subject most prominently dealt with is the slow rate at which the population of France increases. According to the report of a prolonged discussion on this question, there is much difference of opinion as to the causes to which the phenomenon must be attributed. The *Bulletins* also include interesting contributions on the Koubous, a native tribe of Sumatra, by M. Zelle; a series of spoons of various epochs, by M. Capitan; the pre-Columbian ethnography of Venezuela, by Dr. G. Marcano; justice in Ancient Egypt, by M. Ollivier-Beauregard; and religious evolution in the region of the Congo, by M. Clément Rubbens.

THE second part of the Catalogue of Mammalia in the Indian Museum, Calcutta, by Mr. W. L. Sclater, has just been issued. The first part was compiled by Dr. Anderson, the late Super-

intendent. The total number of species included in the Catalogue amounts to 590, of which 276 are found within the Indian Empire, and 314 are exotic.

THE Smithsonian Institution has issued a set of useful directions, by Leonhard Stejneger, for the use of collectors, who, without being herpetological experts, desire to procure for the U.S. National Museum specimens of the reptiles and batrachians which they may be able to gather in the neighbourhood of their residence or while travelling. The same Institution publishes directions for collecting recent and fossil plants, by F. H. Knowlton; and notes on the preparation of rough skeletons, by F. A. Lucas.

STUDENTS will be glad to welcome the fourth edition of Prof. Milnes Marshall's well-known work on "The Frog: an Introduction to Anatomy, Histology, and Embryology." The author explains that the chapter on embryology has been in great part rewritten, and that some new figures have been added. The entire book has been carefully revised.

THE additions to the Zoological Society's Gardens during the past week include a Dorsal Hyrax (*Hyrax dorsalis*) from Sierra Leone, presented by Mr. Reginald Brett; a Common Polecat (*Mustela putorius*), British, presented by Mr. F. D. Lea Smith; a Ring-necked Parrakeet (*Palæornis torquatus*) from India, presented by Mrs. Bowen; an Australian Thicknee (*Œdicnemus grallarius*) from Australia, presented by Sir Ferdinand von Mueller, C.M.Z.S.; a Manx Shearwater (*Puffinus anglorum*), British, presented by Master Riviere.

OUR ASTRONOMICAL COLUMN.

SOLAR OBSERVATIONS.—In *Comptes rendus* for August 24. Prof. Tacchini gives a *résumé* of the solar observations made at the Observatory of the Roman College during the second quarter of this year. Spots and faculæ have been observed on 73 days, viz. 25 in April, 23 in May, and 25 in June, The following are the results obtained:—

1891.	Relative frequency of spots.	Relative frequency of days without spots.	Relative magnitude of spots.	Relative magnitude of faculæ.	Number of groups per day.
April	9·24	0·00	24·56	55·60	2·36
May	14·35	0·00	48·14	51·82	4·09
June	16·88	0·00	47·00	89·38	3·80

The distribution and magnitude of the prominences observed are as follow:—

1891.	Number of days of observation.	Mean number.	Mean height. ″	Mean extension. °
April	18	7·50	42·3	1·5
May	21	4·62	37·3	1·4
June	19	5·53	39·4	1·8

It is worthy of remark that there was a secondary maximum in May in the case of spots, whilst a secondary minimum is indicated by the observations of prominences.

CONNECTION BETWEEN TERRESTRIAL MAGNETISM AND RADIANT SUNLIGHT.—Prof. Frank H. Bigelow contributes a note to the *American Journal of Science* for September, on the causes of the variations of the magnetic needle. He finds, from a discussion of magnetic observations made at thirteen stations during the month of June 1883, that "the permanent magnetic condition of the earth may be principally due to the orbital motion of the earth through the radiant field of sunlight. The rotation of the earth on its axis causes a modification of the direction of the axis of polarization, by diminishing the angle between the two axes, and as the result of the annual motion may cause it to rotate in a secular period about the axis of figure, or if the magnetization has already become set in the body of the earth, may cause a succession of secular waves to sweep over it from east to west, as is shown to be the case in the history of the isogonic lines and the long-period deflections of the needle." This interesting identification of the magnetic and light action of solar radiations is in harmony with the results of the investigations of Maxwell and Hertz. And Prof. Bigelow believes that, by the application of similar considerations to Mercury, he will be able to satisfactorily account for the outstanding motion of this planet's perihelion.

TWO NEW ASTEROIDS.—On August 28, Charlois discovered the 313th minor planet; and Palisa found the 314th two days later.

PHYSICS AT THE BRITISH ASSOCIATION.

THIS Section, as is unfortunately the custom, was housed in an ecclesiastical edifice in which no provision had been made for the exhibition of apparatus or lantern slides by the readers of papers. No doubt, it is impossible always to provide accommodation equal to that furnished two years ago at Newcastle, when the Physical Lecture Theatre of the Durham College of Science, with its appliances, was placed at the disposal of the Section. Still, it should be possible to provide lantern and screen, and provision should be made, when necessary, for partially darkening the room. If there were a guarantee that lantern slides could always be exhibited, many readers of papers would avail themselves of the opportunity to illustrate their communications much more adequately than is possible at present, when the only appliances are a piece of chalk and a diminutive blackboard; *e.g.* on Monday morning the beautiful photographs of Mr. Clayden and Dr. Copeland had to be passed round from hand to hand instead of being exhibited in a manner which would have done justice to their merits. The contents of many of the papers, too, would be much more easily and pleasantly grasped if such a course were adopted.

Unfortunately, some of the leading physicists, notably Sir William Thomson, Lord Rayleigh, and Prof. Fitzgerald, were unable to be present. Prof. Lodge, however, admirably filled the chair, and spared no exertion in the endeavour to clear up points of obscurity or difficulty that arose during the discussion.

In all, some fifty papers and reports were read. In the limited space at our disposal, we regret that it is only possible to refer to communications of general rather than of special scientific interest.

After the President's address on Thursday morning, Prof. Newton communicated a most interesting account of the action of Jupiter on small bodies passing near the planet, in which he showed that if a comet pass in front of Jupiter, owing to the gravitational attraction between the two bodies the kinetic energy of Jupiter will be increased, while that of the comet will be diminished, and may be diminished to such an extent as to cause it to form (though possibly only temporarily) a member of the solar system. On the other hand, if a comet, already a member of the solar system, pass behind Jupiter, the kinetic energy of the planet will be diminished and that of the comet will be increased, and may conceivably be increased under favourable circumstances to such an extent that the comet may no longer remain as a member of the system. Prof. Newton had calculated that of 1,000,000,000 comets from space crossing, in all directions, a sphere equal in diameter to that of Jupiter's orbit, about 1,200 would come near enough to Jupiter to have their period so much diminished as to be less than that of the planet.

Mr. W. E. Wilson read a paper on the absorption of heat in the solar atmosphere, and exhibited some of the apparatus he had used in the investigation. The method of observation employed consisted in allowing the sun's image to transit across the thermo-electric junction of a Boys radio-micrometer. He finds that the solar radiation from the extreme peripheral portion of the disk is distinctly less than that from the central portions. In this respect the sun's radiation differs entirely from that of the moon, in which there is little or no such difference in the illumination of different parts of the surface. This difference is attributable to the absorption of heat in the solar atmosphere, which will necessarily be much more marked for the peripheral than for the central portions of the disk.

Mr. G. H. Bryan presented an elaborate report on researches relative to the second law of thermodynamics, in which is described an exceedingly simple mechanical representation of Carnot's reversible cycle.

Friday was devoted to papers on electrical subjects. Prof. Andrew Gray read a paper on the electro-magnetic theory of the rotation of the plane of polarized light. Sir William Thomson's explanation of the phenomenon rests on the supposition that the ether has embedded in it a large number of small gyrostats. Prof. Gray showed that the ordinary Maxwellian equations for the phenomenon were obtainable on the supposition of the existence of a closed chain of small magnets embedded in the undisturbed medium, which set themselves with their axes in the direction of propagation of the ray as soon as the medium was magnetized in that direction.

This paper was followed by a most interesting communication from the President, in which he gave an account of preliminary experiments to ascertain if the ether is disturbed in the neighbourhood of a rapidly moving body—in other words, to ascertain whether the ether behaves as a viscous fluid. Allusion was first of all made to the experiments of Arago, in which he endeavoured to determine whether or not the ether was stagnant with respect to the earth by measuring the refractive index of a glass prism at different times of the day, when the ether stream (if it exist) will flow in one direction or the opposite through the prism. Arago found no such shift, indicating that the ether was stagnant with reference to the earth. Fresnel, Fizeau, and Michelson had also studied theoretically or experimentally the ratio of so-called "bound" ether to "free" ether. The problem which Prof. Lodge set himself to determine was whether a disk moving with great rapidity would or would not drag after it the ether in its immediate neighbourhood. Two parallel co-axial disks of steel were arranged to spin at an enormous rate. Rays of light from a single source were allowed to fall on a glass plate feebly silvered so that about half the light was transmitted and half reflected. By means of additional reflectors the two beams passed in opposite directions several times round in the space between the two disks, and were then observed in a common telescope and made to give interference bands. In this way, assuming viscosity of the ether, the one beam would have its velocity increased, the other would have its velocity retarded, with the result that a shift of the interference bands would be produced. So far, however, no such shift has been observed.

Prof. D. E. Jones gave an account of some experiments made by him at Bonn on electric waves in wires. Measurements of the electrical disturbance at different points of a wire, in which stationary waves are set up, were made quantitatively by putting a thermo-electric junction in the circuit at different points, and noting the deflection of the galvanometer in its circuit. Several curious results were recorded for which no explanations were forthcoming.

A communication was read from Lord Rayleigh, relating to the reflection of polarized light from liquid surfaces. He finds that the light reflected at the polarizing angle, from clean liquid surfaces, is only very slightly elliptically polarized; if, however, the surface be ever so slightly contaminated, the amount of elliptically polarized light in the reflected beam is enormously increased.

Saturday was devoted principally to the consideration of papers on electrolysis. Mr. Shaw's report on the present state of our knowledge in electrolysis and electro-chemistry included a tabular compilation by Mr. Fitzpatrick of the electrical properties of soluble salts at different temperatures, and for different concentrations.

Mr. J. Brown read a paper on Clausius's theory of electrolytic conduction, and on some recent evidence for the dissociation theory of electrolysis, in which he gave an account of experiments with so-called semi-permeable membranes. The explanation of their filtering qualities simply depends on the membrane acting as a conductor.

Mr. Chattock gave an account of some important quantitative experiments which he had made on the discharge of electricity from points from which he finds that it is the air round the point rather than the metal surface itself which offers resistance to the discharge.

On Monday the meteorological and allied subjects were taken. The Reports of various Committees appointed to deal with meteorological subjects were read.

Dr. Johnstone Stoney read an interesting paper on the cause of double lines in the spectra of gases. He assumes that the molecules are vibrating in more or less complex harmonic curves, and he illustrated the simple case of sodium vapour by means of a pendulum oscillating to and fro, but with an apsidal motion. He stated that the application of astronomical methods of calculation to molecular motions of sodium vapour gives rise to a double D line instead of to a broadening of the line as might at first sight be imagined. In the discussion which followed, Mr. Webster stated that Prof. Michelson, who was endeavouring to determine the metre in terms of the wave-length of light emitted by a vibrating atom, had found by the interference method that all the mercury lines are double.

Dr. Copeland exhibited a model to explain the probable nature of the bright streaks on the moon. He attributes the appearance of the streaks to the existence of transparent spheres on the moon's surface, which reflect the light from the posterior surface so as to be only visible in the line of light.

During the morning the President interpolated some observations dealing with the effect of light in modifying the effect of the gravitational attraction of the sun on small particles. When sunlight falls upon a body, a very small repulsive effect is produced, amounting to about 67 dynes per square metre. Thus, for example, during an eclipse of the moon about 1000 tons are suddenly applied, but this small force is incapable of producing any observable effect on the motion of our satellite. The smaller the body, the larger, of course, the surface exposed relatively to the mass, and therefore the greater should be the effect produced. For a certain size of particle (about that of a grain of dust) the gravitational attraction and light repulsion should balance one another. The effect is clearly independent of distance.

On Tuesday, after the Report of the Committee on Electrical Standards, read by Prof. Carey-Foster, and an account of an elaborate research by Mr. Swinburne on the causes of variation of Clark cells, there was arranged a joint discussion with Section G, on "Units and their Nomenclature," which was opened by the President, who suggested that the discussion should, as far as possible, be confined to electrical units, and that the mechanical units should be left to a later period. He discussed at some length the relative advantages and disadvantages of the various names for the unit of self-induction, secohm, quadrant, henry, &c., and expressed himself as of opinion that the quadrant, which was really an angular measure, but which was frequently used as a linear measure, was very objectionable in that it indicated that the unit of self-induction was a length, when it was perfectly well known not to be a length. He was, therefore, of opinion that some name with a less obvious meaning, such as that of a person, was very desirable. He thought also that the secohm was too large for practical purposes, and that some sub-multiple such as $\frac{1}{1000}$ would be preferable.

The President was followed by Mr. Preece, who referred to the work of the British Association Committee on Electrical Standards, which had lasted now for thirty years, and expressed the opinion that it would be undesirable to interfere in any way with the old standards now about to be legalized by the Board of Trade.

Prof. Stroud read a paper on some revolutionary suggestions on the nomenclature of electrical and mechanical units, in which he advocated selecting 10^9 cm. as the unit of length, 10^{-9} gm. as the unit of mass, and 1 sec. as the unit of time to form the basis of a new practical system of units. He also explained the details of a system of automatic nomenclature for C.G.S. and other units, which he thought should be taken into consideration before any fresh names were authorized. The special feature of the system is that every label is self-explanatory.

Dr. Johnstone Stoney thought the old system should remain intact, and that the proper way to deal with the subject of nomenclature was to indicate sub-multiples by numerical prefixes; *e.g.* he would call a microfarad a sixth farad, and the capacity of a Leyden jar would be about a tenth farad. He suggested that the name for the unit of magnetism should be a Gilbert, and that of the unit magnetic field a Gauss.

Prof. Carey Foster thought that if the volt and ampere were made ten times as great, fresh names, such *e.g.* as "gal," from Galvani, should be introduced.

Prof. Rücker laid stress on the importance of recognizing the fact that we possessed at present no definite knowledge as to the absolute dimensions of any electrical or magnetic unit, and therefore it was undesirable to introduce names (such *e.g.* as quadrant) implying the possession of such knowledge.

Prof. S. P. Thompson drew attention to the desirability of

distinguishing between scalar and vector quantities in our dimensions.

Prof. Gray disapproved of the term electromotive force, but thought it was a term which could scarcely be eradicated now.

Each speaker, in fact, discussed the subject from his own point of view, with the result, as the President remarked, that the time allotted had only served to open the discussion, but he hoped that it would be continued in the technical journals during the year, so that some definite conclusions might be arrived at in 1892.

Wednesday morning was devoted to clearing off arrears.

Prof. S. P. Thompson read two optical papers, one on the measurement of lenses, and a second on a new polarizer. In this instrument the polarization is effected by reflection from black glass, but to avoid the angling of the beam a reflecting prism is used in addition. This arrangement has the disadvantage that the axis of the beam undergoes a translational shift, so that rotation of the polarizer is out of the question. To get over this difficulty two more reflectors are introduced, or two quarter-wave plates may be used, one of which converts the plane polarized light into circularly polarized light, while the other reconverts it into light plane polarized in any azimuth.

Dr. Webster then gave an account of some experiments on a new method for determining v. The method is similar in some respects to Ayrton and Perry's, and gave as a result in the preliminary experiments $2{\cdot}987 \times 10^{10}$.

Prof. Rücker then gave an account of some experiments made by Prof. Ayrton and himself, on the magnetic field near the South London Electrical Railway. The experiments were made in a house in Kennington Park Road with ordinary galvanometers, and showed conclusively that the magnetic disturbances on delicately suspended needles would be perceptible at considerable distances.

Prof. J. V. Jones, in describing some experiments on the periodic time of tuning-forks, maintained in vibration electrically, stated that dry platinum-platinum contacts do not work satisfactorily, whereas the results obtained with mercury contacts are much better, at all events when changes of temperature are carefully guarded against.

Mr. F. T. Trouton described some interesting experiments to determine the rate of propagation of magnetization in iron. A large coil of iron wire, from 8 to 12 feet in diameter, was supplied with one fixed coil wound on it, and through which the alternating current passed. A second exploring coil was connected up with a telephone, and one experiment consisted in endeavouring to find out the positions of nodes and internodes in the magnetized material from which it might have been possible to have determined the length of the wave of magnetization for a definite period of alternation. Nodes were observed in the half of the ring remote from the magnetizing coil, but these were easily ascertained not to be the ones sought for, because their position was not found to depend on the period of alternation.

The President attributed the effects to mechanical vibrations excited by magnetization.

CHEMISTRY AT THE BRITISH ASSOCIATION.

THE proceedings of Section B at Cardiff were not felt to be as interesting as on some previous occasions. Several well-known chemists were not present, and no set discussions on subjects of general chemical interest, which have been special features at other times, took place. Still, in the course of the meeting several papers of very considerable importance were read, and provoked valuable comments. The President's Address was listened to by an enthusiastic audience, and his remarks, together with several of the papers contributed during the meeting, should give a fresh impetus to the study of the metals.

Prof. Dunstan read the Report of the Committee on the Formation of Haloid Salts. It has been found by Mr. Shenstone that chlorine, prepared by the action of hydrogen chloride on manganese dioxide, attacks mercury readily, even when both substances are pure and dry, while that obtained by heating platinous chloride only attacks mercury extremely slowly. Incidentally it has been discovered that pure platinous chloride is a very difficult substance to prepare, an oxychloride being formed at the same time. The results so far obtained are to be regarded as preliminary.

Prof. Vivian B. Lewes read a paper on the spontaneous ignition of coal. His experiments lead him to reject the explanation of Berzelius, which attributes spontaneous ignition to the oxidation of pyrites contained in the coal. The heat given off by the combustion of the pyrites present in the most dangerous kind of coal, even if localized, would not be sufficient to raise the temperature of the adjacent coal to the ignition point. The cause of spontaneous ignition of coal is to be found, rather, in its power, especially when finely divided, of absorbing oxygen, which causes the slow combustion of some of the hydrocarbon constituents even at the ordinary temperature. The action may increase under favourable conditions until ignition of the coal results. The risk is greatest with large masses of coal, and with the ordinary air supply on board ships. The oxidation increases rapidly with the initial temperature of the coal, so that coal fires are found to occur most often on ships frequenting tropical climates. It may be roughly estimated that the absorbing power of a coal for oxygen is proportional to its power of taking up moisture.

In the discussion which followed, Prof. Bedson mentioned his experiments on the heating of coal-dust at various temperatures up to 140° C. He had noticed that in some cases combustible gases were given off by the coal.

A feature of special interest was the exhibition by Ludwig Mond of specimens of nickel-carbon-oxide and metallic nickel obtained therefrom. In the paper read in conjunction with this exhibit an account was given of the discovery and properties of the above compound. The physical properties have been described in the *Journal für physikalische Chemie*. Chemically, nickel carbonyl is most inactive, numerous experiments made to introduce the carbonyl group into organic substances by its means having been uniformly unsuccessful. Experiments were described having for their object the direct extraction of nickel from its ores by means of carbon monoxide. It was found that, as long as the nickel is combined with arsenic or sulphur, the process is entirely successful on a laboratory scale. Such ore, or matte, or speiss, is calcined, reduced by water gas at 450°, cooled down to a suitable temperature, and treated with carbon monoxide in a suitable apparatus. On exposing a heated surface to the gas containing nickel-carbon-oxide, it is possible to produce, direct from such gas, articles of solid nickel, or goods plated with nickel, resembling in every way those obtained by galvanic deposition of metals, and reproducing with the same exactitude and fineness any design upon such articles. This result can also be obtained by immersing heated articles in a solution of nickel-carbon-oxide in such solvents as benzole, petroleum, tar oils, &c., or by applying such solution to the heated articles with a brush or otherwise.

A specimen of iron-carbon-oxide was exhibited, which Messrs. Mond and Langer have obtained as an amber-coloured liquid, which, on standing, deposits tabular crystals of a darker colour, and solidifies entirely below − 21° C. to a mass of needle-shaped crystals. It boils at 102° C., but leaves a small quantity of green-coloured oil behind. Several analyses and vapour-density determinations have been made, but it is not yet certain whether a pure substance has been obtained or a mixture of several iron carbonyls. The authors hope shortly to publish a full account of this interesting substance, which differs considerably in its chemical behaviour from nickel-carbon-oxide.

Mr. Crookes described his experiments on the electrical evaporation of metals and alloys. If a brush of gold is placed in a vacuum tube and connected with the negative pole of an induction coil at ordinary temperature, and if a piece of glass be placed underneath the gold in the tube, on passing the current a metallic mirror appears on the glass, increasing in thickness to a leaf, which can be peeled off, and which is perfectly homogeneous. Films of silver and platinum can also be obtained. It is found that different metals thus treated evaporate at different rates, one or two, such as aluminium and magnesium, being apparently non-volatile. It is thus possible, in the case of the aluminium-gold alloy discovered by Prof. Roberts-Austen, to separate a large portion of the gold from the aluminium by electrical evaporation.

T. Turner gave an account of experiments which he had made to discover the cause of the red blotches which often appear on the surface of brass sheets on rolling, and which are a great source of annoyance to Birmingham manufacturers. They are

due to the erosion of the zinc by the chlorides present in the solution in which the brass has been pickled, and in the water in which it is afterwards washed, care not being always taken to prevent such chlorides from drying on before rolling.

A. P. Laurie described the experiments he has made to determine the electromotive forces of various alloys with a view to establishing the existence of definite compounds among them. His earlier experiments will be found in the Journ. Chem. Soc., 1888, p. 104. His recent work leads him to conclude that a compound of gold and tin of the formula AuSn exists, a sudden rise of electromotive force being observed when the proportion of tin in the alloy exceeds that required by the above formula. Compounds do not appear to exist among the alloys of zinc, cadmium, lead, and tin.

Prof. Roberts-Austen exhibited and described his self-recording pyrometer. In this instrument, thermal junctions of platinum and platinum containing 10 per cent. of rhodium are connected with a galvanometer. The spot of light from the mirror of this is caused to fall on a slit before which a photographic plate passes at a given rate, by which means a curve is traced, corresponding to the variations in temperature of the heated thermal junction. The other junction is kept at a constant temperature by immersion in water. Temperatures up to the melting-point of platinum can be determined with an accuracy of 10°. The curves of cooling of several alloys have been determined. The alloy of gold and aluminium differs from others, such as that of platinum and lead, in that there is no break in the curve at the point of solidification of the alloy.

A paper by A. Vernon-Harcourt and F. W. Humphery was entitled "The Relation between the Composition of a Double-Salt and the Composition and Temperature of the Liquid in which it is formed." The authors have obtained a large number of double chlorides of ammonium and iron by crystallizing from solutions containing varying amounts of ferrous and ammonium chlorides, and maintained at different temperatures. The composition of the salts varied, according to conditions, from two to twenty-one molecules of ammonium chloride combined with one of ferrous chloride. The salts could be obtained well crystallized, and varied considerably from each other in their crystalline habit. The authors suggest that similar complex compounds may exist in other cases.

Prof. Dunstan, in the discussion which followed, described a series of double cyanides of zinc and mercury, of complex composition, which he had obtained by precipitation.

In a preliminary account of some experiments he is making on the action of oxide of cobalt in causing the evolution of oxygen from hypochlorites, Prof. M'Leod showed that, on boiling an alkaline solution of a hypochlorite alone, some oxygen is evolved and chlorate formed, so that the action is probably somewhat complex in presence of oxide of cobalt.

In the absence of Prof. Armstrong, Dr. Morley read the Report on the Isomeric Naphthalene Derivatives. The study of the dichloronaphthalenes has been completed. Of the twelve reported to exist, only ten could be obtained. This number is that required by theory. Of the fourteen theoretically possible trichloronaphthalenes, thirteen have been obtained. The compound containing the chlorine atoms in the positions 1 : 2 : 1′ is missing. These results put it beyond question that naphthalene has a symmetrical structure. Its exact inner configuration has yet to be dealt with. Experiments have been made with a view to determine the manner in which substitution takes place. It appears probable that an addition product is always first formed.

Prof. Rücker gave an account of the experiments made by Prof. Roberts-Austen and himself to determine the specific heat of basalt. The experiments were performed with the aid of the self-recording pyrometer above-mentioned. The results obtained when the substance was heated in a platinum crucible in a gas furnace agreed well together. The specific heat increases regularly up to the melting-point, which is not very definite. About this point there is considerable absorption of latent heat. The mean specific heat between 20° and 470° was found to be ·199; between 470° and 750°, ·244; between 750° and 880°, ·626; and between 880° and 1190°, ·323.

Prof. F. Clowes described an apparatus for testing safety-lamps which permitted economy in the marsh-gas used. It consisted essentially of a large wooden box, rendered gas-tight by paraffin, in which the mixture of fire-damp and air could be made, the safety-lamp being afterwards introduced. A lamp was exhibited which would indicate in this apparatus ·25 per cent. of fire-damp.

Prof. C. M. Thompson described the results he has obtained on repeating the experiments of Krüss and his colleagues on the rare earths, which caused them to announce the probable existence of about twenty new elements. Although he has worked on material from the same locality and of the same appearance as that used by the above-named workers, he has entirely failed to confirm their results, at any rate with regard to the didymium fraction. He considers that the absence of certain lines noticed by them in the didymium spectrum may be due simply to dilution, and do not indicate a splitting up of that element. On making his solutions sufficiently strong, he was able in all cases to obtain the lines.

Prof. Ramsay drew attention to the remarkable properties which are exhibited by the liquids obtained by passing excess of hydrogen sulphide into solutions of certain metals, and afterwards expelling the excess of hydrogen sulphide by hydrogen. Mercuric sulphide treated in this way dissolves to a dark-brown solution. Antimony and arsenic sulphides also dissolve. On examining the mercury solution under the microscope, brown particles are seen in a state of rapid motion. With antimony solution, particles are not visible, but a sort of granular movement is to be seen. With arsenic solution, nothing is visible. On dialysis of the solution, none of the metal diffuses if the solution is pure; in the case of the antimony, diffusion takes place if tartaric acid is present. These solutions are readily precipitated by the addition of certain salts, but, although the antimony solution becomes nearly solid on precipitation, no accompanying rise of temperature can be noticed. Also, no depression of the freezing-point is observed with such a solution. The specific gravity of the solution, however, is higher than that of water. The experiments show the power of the solvent to bring about extremely fine mechanical division of a substance, and suggest the possibility of further atomic or ionic separation. The particles of quasi-dissolved substance are believed to be in a state of rapid but circumscribed motion.

One of the few papers on organic chemistry was read by J. J. Sudborough, on the action of nitrosyl chloride on unsaturated carbon compounds. He has examined the action of nitrosyl chloride on ethylene, propylene, amylene, and cinnamene, crotonic, oleic, erucic, and cinnamic acids. Of these, ethylene is chlorinated, and forms the dichloride $C_2H_4Cl_2$; propylene is practically unacted upon; amylene forms a nitrosochloride, $C_5H_{10}NOCl$, melting at 152°; and cinnamene a similar compound, C_8H_8NOCl, melting at 97°. Crotonic acid is unacted upon, even when heated to 90°, while oleic and erucic acids readily form definite nitrosochlorides, the former melting at 86° and the latter at 92°. Cinnamic acid is unacted upon when cooled, but forms the dichloride $C_9H_8O_2Cl_2$ when heated to 100°. Up to the present the author can find no laws regulating the action of nitrosyl chloride on various carbon compounds.

A paper was read by C. G. Moor, on a new method for the disposal of sewage. This consists in the application of a method invented by Mr. Rees Reece for obtaining tar, ammonia, &c., from peat, to the recovery of similar products from sludge cake. A kind of lime-kiln is employed, with a forced draught, connected to a series of condensers. The operation is conducted in such a manner that the material in the lower part of the furnace is kept in active combustion; its heat distils the material directly above, and this in its turn gradually descends to serve as fuel for the succeeding charge. Eighty per cent. of the theoretical yield of ammonia has been obtained. In order for the process to be commercially successful, it seems that the use of lime in pressing the sludge should be avoided at all costs, as, if much lime is present, the ash obtained in the furnace has a very low value, and clinker is apt to be produced. The author suggests the use of carbonized sludge in powder, mixed with salts of alumina and iron, in place of lime.

A. H. Allen described a curious reaction he had noticed on treating glycerides with alcoholic potash. If the quantity of potash or soda present is insufficient to completely saponify the glyceride, an ethyl salt of the acid is obtained. Thus in the case of butyrin large quantities of ethyl butyrate pass over on distillation. In the case of acetin it was found that no action took place on boiling sodium acetate, acetin, and alcohol together; but, on the addition of a trace of potash, 80 per cent. of the theoretical yield of ethyl acetate was obtained.

SOME DIFFICULTIES IN THE LIFE OF AQUATIC INSECTS.[1]

WE understand insects to be animals of small size, furnished with a hard skin and six legs, breathing by branched air-tubes, and commonly provided in the adult condition with wings. The animals thus organized are pre-eminently a dominant group, as is shown by the vast number of the species and individuals, their universal distribution, and their various habitat.

The insect type, like some fruitful inventions of man—paper or lithography, for instance—has proved so successful that it has been found profitable to adapt it to countless distinct purposes. I propose to consider one only of its infinitely varied adaptations, viz. its adaptation to aquatic life.

There are insects which run upon the earth, insects which fly in the air, and insects which swim in the water. The same might be said of three other classes of animals—the three highest—viz. mammals, birds, and reptiles. But insects surpass all other classes of animals in the variety of their modes of existence. Owing to their small size and hard skin, they can burrow into the earth, into the wood of trees, or into the bodies of other animals. There are some insects which can live in the water, not as the mammal, bird, or reptile does, coming up from time to time to breathe, but constantly immersed, like a fish. This is the more remarkable because insects are, as a class, air-breathers. Air-tubes or tracheæ, branching tubes, whose walls are stiffened by spiral threads, supply all the tissues of the body with air. That such an animal should be hatched in water, and live almost the whole of its life immersed, a thing which actually happens to many insects, is a matter for surprise, and implies many modifications of structure, affecting all parts of the body.

The adaptation of insects to aquatic conditions seems to have been brought about at different times, and for a variety of distinct purposes. Many Dipterous larvæ burrow in the earth. Some of these frequent the damp earth in the neighbourhood of streams; others are found in earth so soaked with water that it might almost be called mud, though they breathe by occasionally taking in atmospheric air. In yet more specialized members of the same order we find that the larva inhabits the mud at the bottom of the stream, and depends for its respiration entirely upon oxygen dissolved in the water. The motive is usually that the larva may get access to the decaying vegetable matter found in slow streams, but some of these larvæ have carnivorous propensities.

Other insects merely dive into the water, coming up from time to time to breathe, or skate upon the surface.

Nearly every order of insects contains aquatic forms, and the total number of such forms is very large. I believe that all are modifications of terrestrial types, and it is probable that members of different families have often betaken themselves to the water independently of one another.

The difficulties which aquatic insects have to encounter begin with the egg. It is in most cases convenient that the egg should be laid in water, though this is not indispensable, and the winged, air-breathing fly is, as a rule, ill-fitted for entering water. Some insect-eggs hatch if they are merely scattered, like grains of sand, over the bottom of a stream, but others must be laid at the surface of the water, where they can gain a sufficient supply of oxygen. If the water is stagnant, it will suffice if the eggs are buoyant, like those which compose the egg-raft of the gnat, but this plan would hardly answer in running streams, which would carry light, floating eggs to great distances, or even sweep them out to sea. Moreover, floating eggs are exposed to the attacks of hungry creatures of various kinds, such as birds or predatory insect larvæ. These difficulties have been met in the cases of a number of insects by laying the eggs in chains or strings, and mooring them at the surface of the water. The eggs are invested by a gelatinous envelope, which swells out, the moment it reaches the water, into an abundant, transparent mucilage. This mucilage answers more than one purpose. In the first place it makes the eggs so slippery that birds or insects cannot grasp them. It also spaces the eggs, and enables each to get its fair share of air and sunlight. The gelatinous substance appears to possess some antiseptic property, which prevents water-moulds from attacking the eggs; for, long after the eggs have hatched out, the transparent envelope remains unchanged. The eggs of the frog, which are laid in the stagnant water of ditches or ponds, float free at the surface, and do not require to be moored. The eggs of many snails are laid in the form of an adhesive band, which holds firmly to the stem or leaf of an aquatic plant. Some insects, too, lay their eggs in the form of an adhesive band. In other cases the egg-chain is moored to the bank by a slender cord.

The common two-winged fly, Chironomus, lays its eggs in transparent cylindrical ropes, which float on the surface of the water. During the summer months these egg-ropes, which are nearly an inch in length, may readily be found on the edges of a stone fountain in a garden, or in a water-trough by the side of the road. The eggs are arranged upon the outside of the rope in loops, which bend to right and left alternately, forming sinuous lines upon the surface. Each egg-rope is moored to the bank by a thread, which passes through the middle of the rope in a series of loops, and then returns in as many reversed and overlapping loops, so as to give the appearance of a lock-stitch. The thread is so tough that it can be drawn out straight with a needle without breaking. If the egg-rope is dipped into boiling water, the threads become apparent, but in the natural state they are invisible, owing to their transparency. The mucilage is held together by the threads interwoven with the mucilage. The loops can be straightened without injury until the length of the rope is almost doubled. If stretched beyond this point the threads become strained, and do not recover their original shape when released. By means of these threads, firmly interwoven with the mucilage of the egg-rope, the whole mass of many hundreds of eggs is firmly moored, yet so moored that it floats without strain, and rises or falls with the stream. The eggs get all the sun and air which they require, and neither predatory insects, nor birds, nor water-moulds, nor rushing currents of water, can injure them.

The eggs of the caddis-fly are laid in larger ropes, which, in some species, are very beautiful objects, owing to the grass-green colour of the eggs. The egg-raft of the gnat, which has often been described, is well suited to flotation in stagnant water, and is freely exposed to the air, a point of unusual importance in the case of an insect which in all stages of growth seems to need the most efficient means of respiration, and whose eggs are usually laid in water of very doubtful purity. The lower or submerged end of each egg opens by a lid, and through this opening the larva at length escapes.

The eggs of water-haunting insects are in many ways particularly well suited for the study of development. The eggs of Chironomus, for instance, can always be procured during the summer months. They are so transparent as to admit of examination under high powers of the microscope as living objects, and as they require no sort of preparation, they may be replaced in the water after each examination to continue their development. This saves all trouble in determining the succession of the different stages—a point which usually presents difficulties to the embryologist. The whole development of the egg of Chironomus is completed in a few days (three to six, according to temperature), and it is therefore an easy matter to follow the process throughout with the help of three or four chains of eggs.

When the larvæ are hatched, and escape into the water, new difficulties arise. Some have to seek their food at the surface of the water, and must yet be always immersed, others live upon food which is only to be found in rapid streams, and these run serious risk of being swept away by the rush of water. All need at least a moderate supply of oxygen, which has either to be drawn from the air at the surface, or extracted from the water by special organs. The difficulty of breathing is, of course, greatly increased when the larva seeks its food at the bottom of foul streams, as is the case with certain Diptera. The larva of Chironomus, for example, feeds upon vegetable matter, often in a state of decay, which is obtained from the mud at the bottom of slow streams, and in this mud the larva makes burrows for itself, cementing together all sorts of materials by the secretion of its salivary glands, drawn out into fine silken threads. The burrows in which the larva lives furnish an important defence against fishes and other enemies, but they still further increase the difficulty of procuring a supply of air. Hence, the larva frequently quits its burrow, especially by night, and swims towards the surface. At these times it loops its body to and fro with a kind of lashing movement, and is thus enabled to advance and rise in the water. From the well-aërated water at the surface of the stream it procures a free supply of oxygen,

[1] Evening Discourse, delivered before the British Association, Cardiff, 1891, by L. C. Miall, Professor of Biology in the Yorkshire College.

which becomes dissolved in the abundant blood of the larva. Four delicate tubes filled with blood, which are carried upon the last segment of the body, are believed to be especially intended for the taking up of dissolved oxygen. The tracheal system is rudimentary and completely closed, and hence gaseous air cannot be taken into the body. The dissolved oxygen, procured with much exertion and some risk, must be stored up within the body of the larva, and used with the greatest economy. It is apparently for this reason that the larva of Chironomus contains a blood-red pigment, which is identical with the hæmoglobin of vertebrate animals. The hæmoglobin acts in the Chironomus larva as it does in our own bodies, as an oxygen-carrier, readily taking up dissolved oxygen, and parting with it gradually to the tissues of the body.

It is instructive to notice that only such Chironomus larvæ as live at the bottom and burrow in the mud possess the red hæmoglobin. Those which live at or near the surface have colourless blood, and a more complete, though still closed, tracheal system. The larva of the carnivorous Tanypus, which is found in the same streams, but does not burrow, has a much more complete tracheal system, and only enough hæmoglobin to give a pale red tint to the body. The larva of the gnat again, which has a large and open tracheal system, and in all stages of growth inhales gaseous air, has no hæmoglobin at all. A list of the many animals of all kinds which contain hæmoglobin, shows that for some reason or another each of them requires to use oxygen economically. Either the skin is thick, and the respiratory surface limited, or they are inclosed in a shell, or they burrow in earth or mud. We might expect to find that hæmoglobin would always be developed in the blood of animals whose respiration is rendered difficult in any of these ways, but any such expectation would prove to be unfounded, and there are many animals whose mode of life renders it necessary that oxygen should be stored and economically used, which contain no hæmoglobin in their blood. Hence, while we have a tolerably satisfactory reason for the occurrence of hæmoglobin in a number of animals whose respiratory surface is limited, and whose surroundings make it a matter of difficulty to procure a sufficient supply of oxygen, we have to admit that many similar animals under the same conditions manage perfectly well without hæmoglobin. Such admission is not a logical refutation of the explanation. I might fairly put forward the baldness of mankind as at least the principal reason for wearing wigs, and this explanation would not be impaired by any number of cases of bald men who do not wear wigs. The fact is that the respiratory needs, even of closely allied animals, vary greatly, and further, there are more ways than one of acquiring and storing up oxygen in their bodies.

Either the storage-capacity for oxygen of the Chironomus larva is considerable, or it must be used very carefully, for the animal can subsist long without a fresh supply. I took a flask of distilled water, boiled it for three-quarters of an hour, closed it tight with an india-rubber bung, and left it to cool. Then six larvæ were introduced, the small space above the water being at the same time filled up with carbonic acid. The bung was replaced, and the larvæ were watched from day to day. Four of the larvæ survived for forty-eight hours, and one till the fifth day. Two of them changed to pupæ. Nevertheless, the water was from the first exhausted of oxygen, or nearly so.

The Chironomus larva is provided with implements suited to its mode of life. The head, which is extremely small and hard, carries a pair of stout jaws, besides a most complicated array of hooks, some fixed, some movable. The use of these minute appendages cannot always be assigned, but some of them are apparently employed to guide the silky threads which issue from the salivary glands. The first segment behind the head carries a pair of stumpy legs, which are set with many hooks. These are mainly used in progression, and help the larva to hitch itself to and fro in its burrow. A similar, but longer pair of hooked feet is found at the end of the body. This hinder pair serves to attach the animal to its burrow when it stretches forth in search of food.

Creeping aquatic larvæ, such as Ephydra, possess several pairs of legs in front of the last pair, but the burrowing species, such as caddis-worms, agree with Chironomus, not only in their mode of life, but also in the reduction of the abdominal legs to a single pair, which are conspicuously hooked.

The larval head in this, as in many other aquatic insects, is far smaller and simpler than that of the fly. The larval head is little more than an implement for biting and spinning, by no means such a seat of intelligence as it is in higher animals. In Chironomus it contains no brain; the eyes are mere specks of pigment, and the antennæ are insignificant. But the head of the fly incloses the brain, and bears elaborate organs of special sense—many-facetted eyes, and in the male beautiful plumed antennæ. This difference in size and complexity probably explains the fact that the head of the fly is not developed within the larval head, but in the thorax. It is only at the time of pupation that it becomes everted, and its appendages assume the position which they are ultimately intended to occupy.

At length the Chironomus wriggles out of the larval skin, and is transformed into a pupa. It no longer requires to feed, and the mouth is completely closed. It is equally unable to burrow, and usually lies on the surface of the mud. Two tufts of silvery respiratory filaments project from the fore-end of the body just behind the future head, and these wave to and fro in the water, as the animal alternately flexes and extends its body. At the tail-end are two flaps, fringed with stout bristles, which form a kind of fan. The pupa virtually consists of the body of the fly, inclosed within a transparent skin. The organs of the fly are already complete externally, and even in microscopic detail they very closely resemble those of the perfect animal. These parts are, however, as yet very imperfectly displayed. The wings and legs are folded up along the sides of the body, and are incapable of independent movement. For two or three days there is no outward change, except that the pupa, which originally had the blood-red colour of the larva, gradually assumes a darker tint. The tracheal system, which was quite rudimentary in the larva, but is now greatly enlarged, becomes filled with air, secreted from the water by the help of the respiratory tufts, and the pupa floats at the surface. At last the skin of the back splits, the fly extricates its limbs and other appendages, pauses for a moment upon the floating pupa-case, as if to dry its wings, and then flies away.

This fly is a common object on our window panes, and would be called a gnat by most people. It can be easily distinguished from a true gnat by its habit of raising the fore-legs from the ground when at rest. It is entirely harmless, and the mouth-parts can neither pierce nor suck. Like many other Diptera, the flies of Chironomus associate in swarms, which are believed in this case to consist entirely of males. The male fly has plumed antennæ with dilated basal joints. In the female fly the antennæ are smaller and simpler, as well as more widely separated.

In brisk and lively streams another Dipterous larva may often be found in great numbers. This is the larva of Simulium, known in the winged state as the sand-fly. The Simulium larva is much smaller than that of Chironomus, and its blood is not tinged with red. The head is provided with a pair of ciliary organs, fan-like in shape, consisting of many longish filaments, and borne upon a sort of stem. The fringed filaments are used to sweep the food into the mouth. The larva of Simulium subsists entirely upon microscopic plants and animals. Among these are great numbers of Diatoms, and the stomach is usually found half full of the flinty valves of these microscopic plants. The Simulium larva seeks its food in rapid currents of water, and a brisk flow of well-aërated water has apparently become a necessity to it. If the larvæ are taken out of a stream and placed in a vessel of clear water, they soon become sluggish, and in warm weather do not survive very long. It matters little, however, to the larvæ whether the water in which they live is pure or impure; and streams which are contaminated with sewage often contain them in great abundance. There are no externally visible organs of respiration, but the skin is supplied by an abundant network of fine tracheal branches, which, no doubt, take up oxygen from the well-aërated water in which the animal lives. From this network at the surface, branches pass to supply all the internal organs. The Simulium larva is found upon aquatic weeds, and the pair of hind-feet, which in Chironomus were shaped so as to enable the larva to hold on to its burrow, here become altered, so as to furnish a new means of attachment. The two feet are completely united into one. The two clusters of hooks found in the Chironomus larva form now a circular coronet, and the centre of the inclosed space becomes capable of being retracted by means of muscles which are inserted into it from within. The larva is thus enabled to adhere to the smooth surface of a leaf, holding on by its sucker, which is, no doubt, aided by the circle of sharp hooks. Efficient as this adhesive organ undoubtedly is, it must be liable to derangement by occasional accidents, as, for instance, if there

should be a sudden rush of water of unusual violence, or if the larva should be obliged to quit its hold in order to avoid some dangerous enemy. In the case of such an accident it is not easy to see how it will ever recover its footing. Swept along in a rapid current, we might suppose that there would be but a slender probability of its ever finding itself favourably placed for the application of its sucker and hooks. But such emergencies have been carefully provided for. The salivary glands, or silk-organs, which the Chironomus larva uses in weaving the wall of its burrow, furnish to the Simulium larva long mooring-threads, by means of which it is anchored to the leaf upon which it lives. Even if the larva is dislodged, it is not swept far by the stream, and can haul itself in along the mooring-thread in the same way that a spider or a Geometer larva climbs up the thread by which, when alarmed, it descended to the ground.

When the time for pupation comes, special provision has to be made for the peculiar circumstances in which the whole of the aquatic life of the Simulium is passed. An inactive and exposed pupa, like that of Chironomus, may fare well enough on the soft muddy bottom of a slow stream, but such a pupa would be swept away in a moment by the currents in which Simulium is most at home. When the time of pupation draws near, the insect constructs for itself a kind of nest, not unlike in shape the nest of some swallows. This nest is glued fast to the surface of a water-weed. The salivary glands, which furnished the mooring-threads, supply the material of which the nest is composed. Sheltered within this smooth and tapering case, whose pointed tip is directed up-stream, while the open mouth is turned down-stream, the pupa rests securely during the time of its transformation.

When the pupa-case is first formed, it is completely closed and egg-shaped, but, when the insect has cast the larval skin, one end of the case is knocked off, and the pupa now thrusts the fore-part of its body into the current of water. The respiratory filaments, which project immediately behind the future head, just as in Chironomus, draw a sufficient supply of air from the continually changed water around. The rings of the abdomen are furnished with a number of projecting hooks, which are able to grasp such objects as fine threads. The interior of the cocoon is felted by a number of silken threads, and by means of these the pupa gets an additional grip of its case. If it is forcibly dislodged, a number of the silken threads are drawn out from the felted lining of the case. The fly emerges into the running water, and I do not know how it manages to do so without being entangled in the current of water, and swept down the stream. The pupa-skin splits open just as it does in Chironomus, but remains attached to the cocoon.

The larva of the gnat is perhaps more familiar to naturalists of all kinds than any other aquatic Dipterous insect. The interesting description, and, above all, the admirable engravings, of Swammerdam, now more than two hundred years old, are familiar to every student of Nature.

The larva, when at rest, floats at the surface of stagnant water. Its head, which is provided with vibratile organs suitable for sweeping minute particles into the mouth, is directed downwards, and, when examined by a lens in a good light, appears to be bordered below by a gleaming band. There are no thoracic limbs. The hind-limbs, which were long and hooked in the burrowing Chironomus larva, and reduced to a hook-bearing sucker in Simulium, now disappear altogether. A new and peculiar organ is developed from the eighth segment of the abdomen. This is a cylindrical respiratory siphon, traversed by two large air-tubes, which are continued along the entire length of the body, and supply every part with air. The larva ordinarily rests in such a position that the tip of the respiratory siphon is flush with the surface of the water, and, thus suspended, it feeds incessantly, breathing uninterruptedly at the same time. When disturbed, it leaves the surface by the sculling action of its broad tail. Once below the surface, it sinks slowly to the bottom by gravity alone, which shows that the body is denser than the water. We have, therefore, to explain how it is enabled to float at the surface when at rest. The larva does not willingly remain below for any length of time. It rises by a jerking movement, striking rapid blows with its tail, and advancing tail foremost. When it reaches the top, it hangs as before, head downwards, and resumes its feeding operations.

In order to explain how the larva hangs from the surface against gravity, I must trouble you with some account of the properties of the surface-film of water. You will readily believe that I have nothing new to communicate on this subject, and I venture to show you a few very simple experiments, merely because they are essential to the comprehension of what takes place in the gnat.[1]

In any vessel of pure water, the particles at the surface, though not differing in composition from those beneath, are nevertheless in a peculiar state. I will not travel so far from the region of natural history as to offer any theoretical explanation of this state, but will merely show you experimentally that there is a surface-film which resists the passage of a solid body from beneath. [Mensbrugghe's float shown.] You see (1) that the float is sufficiently buoyant to rise well out of the water; (2) that, when forcibly submerged, it rises with ease through the water as far as the surface-film; (3) that it is detained by the surface-film, and cannot penetrate it. The wire pulls at the surface-film and distorts it, but is unable to free itself. In the same way the surface-film resists the passage of a solid body which attempts to penetrate it from above. This will be readily seen if we throw a loop of aluminium wire upon the surface of water. [Experiment shown.] The loop of wire floats about like a stick of wood. Aluminium is, of course, much lighter than iron, but the floating of this little bar does not mean that it has a lower density than that of water. If the bar is once wetted, it sinks to the bottom and remains there. Even a needle may, with a little care, be made to float upon the surface of perfectly pure water. Still more readily can a piece of metallic gauze be made to float on water. [Experiment shown.] Air can pass through the meshes with perfect ease; water also can pass through the meshes with no visible obstruction. But the surface-film, bounding the air and water, is entirely unable to traverse even meshes of appreciable size. These simple experimental results will enable us to appreciate certain facts of structure, which would otherwise be hard to understand, and which have been wrongly explained by naturalists of the greatest eminence, to whom the physical discoveries of this century were unknown.

We may now try to answer three questions about the larva of the gnat, viz. :—

(1) How is it able to break the surface-film when it swims upwards?

(2) How is it able to remain at the surface without muscular effort, though denser than water?

(3) How is it able to leave the surface quickly and easily when alarmed?

The tip of the respiratory siphon is provided with three flaps, two large and similar to one another, the third smaller and differently shaped. These flaps can be opened or closed by attached muscles. When open, they form a minute basin, which, though not completely closed, does not allow the surface-film of water to enter. When closed, the air within the siphon is unable to escape. At the time when the larva rises to the surface, the pointed tips of the flaps first meet the surface-film, and adhere to it. The attached muscles then separate the flaps, and in a moment the basin is expanded and filled with air. The surface-film is now pulling at the edges of the basin, and the pull is more than sufficient to counterbalance the greater density of the body of the larva, which accordingly hangs from the surface without effort. When the larva is alarmed, and wishes to descend, the valves close, their tips are brought to a point, and the resisting pull of the surface-film is reduced to an unimportant amount. [Living larvæ shown by the lantern.]

Swammerdam found it necessary, in explaining the flotation of the larva of the gnat to suppose that the extremity of its siphon was supplied with an oily secretion which repelled the water. No oil-gland can be discovered here or elsewhere in the body of the larva, and indeed no oil-gland is necessary. The peculiar properties of the surface-film explain all the phenomena. The surface-film is unable to penetrate the fine spaces between the flaps for precisely the same reason that it is unable to pass through the meshes in a piece of gauze.

After three or four moults the larva is ready for pupation. By this time the organs of the future fly are almost completely formed, and the pupa assumes a strange shape, very unlike that of the larva.

At the head-end is a great rounded mass, which incloses the wings and legs of the fly, beside the compound eyes, the mouth-parts, and other organs of the head. At the tail-end is a pair

[1] A number of other experiments, illustrating the properties of the surface-film of water, are described by Prof. Boys in his delightful book on "Soap Bubbles."

of flaps, which form an efficient swimming-fan. The body of the pupa, like that of the larva, is abundantly supplied with air-tubes, and a communication with the outer air is still maintained, though in an entirely different way. The air-tubes no longer open towards the tail, as in the larva, but towards the head. Just behind the head of the future fly is a pair of trumpets, so placed that in a position of rest the margins of the trumpets come flush with the surface of the water. Floating in this position, the pupa remains still, sô long as it is undisturbed, but if attacked by any of the predatory animals which abound in fresh waters, it is able to descend by the powerful swimming movements of its tail fin.

Not that the descent is without its difficulties. The pupa is not like the larva, denser than water, but buoyant. There are two respiratory tubes in the pupa, whereas there is only one in the larva, and to these two tubes the surface-film clings with a tenacity of which only experiment can give an adequate idea. Will you allow me to give you a little more borrowed physics?

If we take a solid body, capable of being wetted by water, and place it in water, the surface-film will adhere to the solid. If the solid is less dense than the water, it will float with part of its surface out of the water. Under such circumstances the surface-film will be drawn upwards around the solid, and will therefore pull the solid downwards. But if the solid is denser than the water, the surface-film around the solid will be pulled downwards, and will pull the solid upwards. Suppose that a solid of the same density as water floats with part of its surface in contact with air, and that weights are gradually added to it. The result will be that the surface of the water around the upper edge of the solid will become more and more depressed. The sides of the depression will take a more vertical position, until at last the upward pull of the film becomes unable to withstand further increase of weight. If this point is passed, the solid will sink. Before this point is attained, we shall have the solid, though denser than water, kept at the surface by the pull of the surface-film.

This state of things may be illustrated by a model. [Float with glass tube attached to its upper surface.] You will readily see that the float has to be weighted appreciably in order to break the connection of the tube with the surface-film. Now the pupa of the gnat has a pair of tubes which are in like manner attached to the surface of the water. When it requires to descend, the pull of the surface-film would undoubtedly be considerable. Adding weight to the body is, of course, impossible, and a great exertion of muscular force would be wasteful of energy, even if it could be put forth. The gnat deals with its difficulty in a neater way than this, and saves its muscular power for other occasions. Let me show you a method of freeing the float from the surface, which was suggested by observation of what was seen in the pupa of the gnat. A thread wetted with water is drawn over the mouth of each tube. It cuts the connection with the surface, and the float, loaded so as to be denser than water, goes down at once. Meinert has described a pencil of hairs which appear to perform the same office for the pupa of the gnat. The hairs draw a film of water over the open mouth of each respiratory tube, and muscular contraction, used moderately and economically, does the rest. When the pupa again comes to the surface the tubes are overspread by a glistening film of water. This is partially withdrawn by a movement of the hairs, so that a chink appears by which air can be slowly renewed. When the insect is completely tranquil, the hairs appear to withdraw more completely, and the tube suddenly becomes free of all film. The act of opening or closing the film is so rapid—like the wink of an eye—that I cannot pretend to have observed more than the closed tube, the slightly open tube, and then the sudden change to a completely open condition. [Living pupæ shown by the lantern.]

Another Dipterous larva described and admirably figured by Swammerdam is the larva of Stratiomys, a larva which, as the structure of the fly shows, belongs to an altogether different group from Chironomus, Simulium, or the gnat. Though only remotely connected with the gnat in the systems of zoologists, the Stratiomys larva has learned the same lesson, and is equally well fitted to take advantage of the peculiar properties of the surface-film. The tail-end of the Stratiomys larva is provided with a beautiful coronet of branched filaments. When this coronet is extended, it forms a basin open to the air and impervious to water, by reason of the fineness of the meshes between the component filaments. Were the larva provided with a basin of the same proportions formed out of continuous membrane, it might float and breathe perfectly well, but the old difficulty would come back, viz. that of freeing itself neatly and quickly when some sudden emergency required the animal to leave the surface. As it is, the plumed filaments collapse and their points approach; the side-branches are folded in, and the basin is in a moment reduced to a pear-shaped body, filled with a globule of air, and reaching the surface of the water only by its pointed extremity. Down goes the Stratiomys larva at the first hint of danger, swimming through the water with swaying and looping movements, somewhat like those of Chironomus. When the danger is past, it ceases to struggle, and floats again to the surface. The pointed tip of its tail-fringe pierces the surface-film, the filaments separate once more, and the floating basin is restored.

The larva of Stratiomys is extremely elongate. The length of its body has evidently some relation to the mode of life of the larva, but none at all to that of the fly which is formed within it. The pupa is so much smaller than the larva as to occupy only the fore-part of the space within the larval skin.[1] The interval becomes filled with air, and during the pupal stage the animal floats at the surface within the empty larval skin.

Stratiomys, both in its larval and pupal states, floats at the surface of the water. The larva can descend into the water when attacked, but the pupa is too buoyant, and too much encumbered by its outer case, to execute any such manœuvre. Provision has accordingly to be made for the protection of the helpless pupa against its many enemies. It is probable that hungry insects and birds mistake the shapeless larval skin, floating passively at the surface, for a dead object. The considerable space between the outer envelope, or larval skin, and the body of the pupa may keep off others, for the first bite of a Dytiscus or dragon-fly larva would be disappointing. Still further security is gained by the texture of the larval skin itself. The cuticle consists of two layers. The inner is comparatively soft and laminated, while the outer layer is impregnated with calcareous salts, and extremely hard. The needful flexibility is obtained by the subdivision of the hard outer layer. Seen from the surface, it is broken up into a multitude of hexagonal fields, each of which forms the base of a conical projection, reaching far into the softer layer beneath. The conical shape of these calcareous nails allows a certain amount of bending of the cuticle, while the whole exposed surface is protected by an armour, in which even the pointed mandibles of a Dytiscus larva can find no effective chink.

The larva and pupa of the Dipterous fly, *Ptychoptera paludosa*, exhibit some interesting adaptations of the tracheal system to unusual conditions. The larva is found in muddy ditches, where it buries itself in the black ooze to a depth of an inch or two. Here, of course, it can procure no oxygen, either gaseous or dissolved. When it requires a fresh supply, it must reach the surface with part of its body, and to enable it to do so with the least possible exertion, the tail-end of the body is made telescopic, like that of another and still more familiar Dipterous larva, Eristalis. The last segments are drawn out very fine, and are capable of a very great amount of retraction or expansion. No visible opening for the admission of air has been discovered, nor do the hairs form a floating basin, as in the Stratiomys larva. The larva may be often seen lying just beneath the surface, which is broken by the tip of the tail. Whether air can be admitted here by some very minute orifice, or whether it is renewed by the exchange of gases through a thin membrane, I cannot as yet venture to say. In shallow water the larva may be occasionally found lying on or in the mud, and stretching out its long tail to the surface. In deeper water, it often floats at the surface.

Two tracheal trunks run along the whole length of the body, including the slender tail, where they are extremely convoluted and unbranched. Towards the middle of the body the tracheæ become greatly enlarged in the centre of each segment, the intervening portions, from which many branches are given off, being comparatively narrow. Each tube, therefore, resembles a row of bladders connected by small necks. A cross-section shows that the tubes are not cylindrical, but flattened, and that, while the lower surface is stiffened by the usual parallel thickenings, the upper surface is thrown into two deep, longitudinal furrows, so that it is readily inflated, becoming circular in section, and readily collapses again when the air is expelled. It seems likely

[1] So singular is the disproportion between the larva and the pupa that some naturalists have actually described the latter as a parasite (Westwood's "Mod. Classification of Insects," vol. ii. p. 532).

that the buoyancy of the larva can thus be regulated, and a larger or smaller quantity of air taken in as desired.

The pupa has a pair of respiratory tubes, which are carried, not on the tail, but on the thorax, close behind the head. One of these tubes is very long, the other very short. The long tube is twice as long as the body, and tapers very gradually to its free tip. Here we find a curious radiate structure, rather like the teeth of a moss-capsule, which seems adapted for opening and closing. There is, however, no orifice which the most careful scrutiny has succeeeded in discovering. A delicate membrane extends between the teeth, and prevents any passage inwards or outwards of air in mass. The tube incloses a large trachea, the continuation of one of the main tracheal trunks. This is stiffened by a spiral coil, but at intervals we find the coil deficient, while the wall of the tube swells out into a thin bladder. However the tube is turned, a number of these bladders come to the surface. As the pupa lies on the surface of the mud, the filament floats on the top of the water, and the air is renewed without effort through the thin-walled bladders.

Why should the position of the respiratory organs be changed from the tail-end in the larva to the head-end in the pupa? Chironomus, the gnat, Corethra, and many other aquatic insects exhibit the same phenomenon. Evidently there must be some reason why it is more convenient for the larva to take in air by the tail, and for the pupa to take in air by the head. Let us consider the case of the larva first. Where it floats from the surface, or pushes some part of its body to the surface, it is plain that the tail must come to the top and bear the respiratory outlet, for the head bears the mouth and mouth-organs, and must sweep to and fro in all directions, or even bury itself in the mud in quest of food. To divide the work of breathing and feeding between the opposite ends of the body is of obvious advantage, for the breathing can be done best at the top of the water, and the feeding at the bottom, or at least beneath the surface. Such considerations seem to have fixed the respiratory organs at the tail of the larva. Why, then, need this arrangement be reversed when the insect enters the pupal stage? There is now no feeding to be done, and it surely does not signify how the head is carried. Why should not the pupa continue to breathe like the larva, by its tail, instead of developing a new apparatus at the opposite end of its body, as if for change's sake? Well, it does not appear that, so far as the pupa itself is concerned, any good reason can be given why the larval arrangement should not continue. But a time comes when the fly has to escape from the pupa-case. The skin splits along the back of the thorax, and here the fly emerges, extricating its legs, wings, head, and abdomen from their close-fitting envelopes. The mouth-parts must be drawn backwards out of their larval sheaths, the legs upwards, and the abdomen forwards, so that there is only one possible place of escape, viz. by the back of the thorax, where all these lines of movement converge. If, then, the fly must escape by the back of the thorax, the back of the thorax must float uppermost during at least the latter part of the pupal stage. Otherwise the fly would emerge into the water instead of into the air. Granting that the back of the thorax must float uppermost in the pupal condition, it is clear that here the respiratory tubes must be set.

I need hardly speak of the many insects which run and skate on the surface of the water in consequence of the peculiar properties of the surface-film. They are able to do so, first, by reason of their small size; secondly, because of the great spread of their legs; and thirdly, on account of the fine hairs with which their legs are provided. The adhesion of the surface-film is measured by the length of the line of contact, and accordingly the multiplication of points of contact may indefinitely increase the support afforded by the surface of the water.

In the case of very small insects, it becomes possible, not only to run on the surface of the water, but even to leap upon it, as upon a table. This is particularly well seen in one of the smallest and simplest of all insects—the little black Podura, which abounds in sheets of still water. The minute and hairy body of the Podura is incapable of being wetted, and the insect frisks about on the silvery surface of a pond, just as a house-fly might do on the surface of quicksilver. This is all very well so long as the Podura is anxious only to amuse itself, or move from place to place, but it has to seek its food in the water, and, indeed, the attractiveness of a sheet of water to the Podura lies mainly in the decaying vegetation far below the surface. But if the insect is thus incapable of sinking below the surface, how does it ever get access to its submerged food? I have endeavoured to arrive at the explanation of this difficulty by observation of Poduras in captivity. If you place a number of Poduras in a beaker half full of water, they are wholly unable to sink. They run about and leap upon the surface, as if trying to escape from their prison, but sink they cannot. I have chased them about with a small rod until they became excited and much alarmed, but they were wholly unable to descend. Even when large quantities of alcohol were added to the water, the dead bodies of the Podura are seen floating at the top, almost as dry as before. It is only when they are placed upon the surface of strong alcohol that the dead bodies become wetted, and after a considerable time are seen to sink. How, then, does the Podura ever descend to the depths where its food is found?

I found it an easy matter to make a ladder, by which the Poduræ could leave the upper air. A few plants of duck-weed introduced into the beaker enabled them at pleasure to pull themselves forcibly through the surface-film, and climb down the long root hanging into the water like a rope. Once below the surface, the Podura, though buoyant, is enabled, by muscular exertion, to swim downwards to any depth.

Other aquatic insects, not quite so minute as the Podura, experience something of the same difficulty. A Gyrinus, or a small Hydrophilus, finds it no easy matter to quit the surface of the water, and is glad of a stem or root to descend by.

To leave our aquatic insects for a moment, we may notice the habit of creeping on the under-side of the surface-film, which is so often practised by leeches, snails, cyclas, &c. I find this is often described as creeping on the *air*, and some naturalists of the greatest eminence, speak of fresh-water snails as creeping "on the stratum of air in contact with the surface of the water."[1] The body of the animal is, nevertheless, wholly immersed during this exercise, as may be shown by a simple experiment. If Lycopodium powder is sprinkled over the water, the light particles are not displaced by the animal as it travels beneath. The possibility of creeping in this manner depends, not upon any "repulsion between the water and the dry surface of the body," to quote an explanation which is often given, but upon the tenacity of the surface-film, which serves as a kind of ceiling to the water-chamber below. The body of the leech is distinctly of higher specific gravity than the water, and falls quickly to the bottom, if the animal loses its hold of the surface-film. The pond-snails, however, actually float at the surface, and if disturbed, or made to retract their foot, they merely turn over in the water.

What is the result of all the expedients which have enabled air-breathing insects to overcome the difficulties of living in water? They have been successful, we might almost say too successful, in gaining access to a new and ample store of food. Aquatic plants, minute animals, and dead organic matter of all kinds abound in our fresh waters. Accordingly the species of aquatic insects have multiplied exceedingly, and the number of individuals in a species is sometimes surprisingly high. The supply of food thus opened out is not only ample, but in many cases very easy to appropriate. Accordingly the head of the larva degenerates, becomes small and of simple structure, and may be in extreme cases reduced to a mere shell, not inclosing the brain, and devoid of eyes, antennæ, and jaws. The organs of locomotion also commonly afford some indications of degeneration. Where the insect has to find a mate, and discover suitable sites for egg-laying, the fly at least must possess some degree of intelligence, keen sense-organs, and means of rapid locomotion. But some few aquatic insects, as well as some non-aquatic species which have found out an unlimited store of food, manage to produce offspring from unfertilized eggs, and to have these eggs laid by wingless pupæ or hatched within the bodies of wingless larvæ. The development of the winged fly, the whole business of mating, and even the development of the embryo within the egg, have thus, in particular insects, been abbreviated to the point of suppression. This is what I mean by saying that the pursuit of a new supply of food has in the case of certain aquatic insects proved even too successful. Abundant food, needing no exertion to discover or appropriate it, has led in a few instances to the almost complete atrophy of those higher organs and functions which alone make life interesting.

The degeneration of aquatic insects, however, very rarely reaches this extreme. In nearly all cases the pupa is succeeded by a fly, whose activity is in striking contrast to the sluggishness

[1] Semper's "Animal Life," Eng. trans., p. 205, and note 97.

of the larva. They differ, to the eye at least, almost as much as air differs from water.

Of the friends to whom I am indebted for help, I must specially name my fellow-worker, Mr. Arthur Hammond, who has communicated to me many results of his own observations, and has drawn most of the illustrations shown this evening. My colleague, Dr. Stroud, has very kindly arranged, and in some cases devised, the physical experiments which have been so helpful to us.

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The Cambridge University Press announces:—"Catalogue of Scientific Papers Compiled by the Royal Society of London," new series for the years 1874–1883; "The Collected Mathematical Papers of Arthur Cayley, Sc.D., F.R.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge," Vol. IV. (to be completed in ten volumes); "A History of the Theory of Elasticity and of the Strength of Materials," by the late I. Todhunter, F.R.S., edited and completed by Karl Pearson, Professor of Applied Mathematics, University College, London—Vol. II. "Saint Venant to Sir William Thomson"; "A Treatise on Elementary Dynamics," new and enlarged edition, by S. L. Loney, Fellow of Sidney Sussex College; "Solutions of the Examples in a Treatise on Elementary Dynamics," by the same author; "A Treatise on Thermodynamics," by J. Parker, Fellow of St. John's College, Cambridge; "A History of Epidemics in Britain," Vol. I., from A.D. 664 to the extinction of Plague in 1666, by Charles Creighton, M.D., formerly Demonstrator of Anatomy in the University of Cambridge; "Catalogue of Type Fossils in the Woodwardian Museum, Cambridge," by H. Woods, of St. John's College, with preface by Prof. T. McKenny Hughes; "Examination Papers for Entrance and Minor Scholarships and Exhibitions in the Colleges of the University of Cambridge"—Part I. Mathematics and Science, Part II. Classics, Mediæval and Modern Languages, and History (Michaelmas Term, 1890), Part III. Mathematics and Science, Part IV. Classics, Law, and History (Lent Term, 1891); and three volumes in the Pitt Press Mathematical Series—"An Elementary Treatise on Plane Trigonomentry for the Use of Schools," by E. W. Hobson, Fellow of Christ's College, Cambridge, and University Lecturer in Mathematics, and C. M. Jessop, Fellow of Clare College; "Arithmetic for Schools," by C. Smith, Master of Sidney Sussex College, Cambridge; "Solutions to the Exercises in Euclid, Books I.—IV.," by W. W. Taylor.

The Clarendon Press promises "Geography of Africa South of the Zambesi," by W. Parr Greswell; "Mathematical Papers of the late Henry J. S. Smith, Savilian Professor of Geometry in the University of Oxford," with portrait and memoir, 2 vols.; "Plane Trigonometry, without Imaginaries," by R. C. J. Nixon; "A Treatise on Electricity and Magnetism," by J. Clerk Maxwell, new edition; "A Manual of Crystallography," by M. H. N. Story-Maskelyne; "Elementary Mechanics," by A. L. Selby; "Weismann's Lectures on Heredity," Vol. II., edited by E. B. Poulton, F.R.S.

During the coming winter Mr. Edward Arnold proposes to issue a series of popular papers on Animals, by Prof. C. Lloyd Morgan, the well-known author of "Animal Life and Intelligence"; "A Treatise on the Standard Course of Elementary Chemistry," by E. J. Cox, Head Master of the Technical School, Birmingham; and a series of scientific works, by Doctor Wormell (the series will embrace text-books of Mechanics, Sound, Light, Heat, Magnetism and Electricity).

Messrs. Longmans, Green, and Co. announce a new volume of "Fragments of Science: being Detached Essays, Addresses, and Reviews," by John Tyndall, F.R.S. "About Ceylon and Borneo: being an Account of Two Visits to Ceylon, One Visit to Borneo, and how I Came Home and was Rocked to Sleep on the Bosom of—well, 'The Suez Canal,'" by Walter J. Clutterbuck, author of "The Skipper in the Arctic Seas," and joint author of "Three in Norway," and "B.C. 1887," with illustrations; "Anthropological Religion," the Gifford Lectures delivered before the University of Glasgow in 1891, by F. Max Müller; "An Introduction to Human Physiology," being the substance of lectures delivered at the St. Mary's Hospital Medical School from 1885 to 1890, by Augustus D. Waller; "Elements of Materia Medica and Therapeutics," with numerous illustrations, by C. E. Armand Semple, M.R.C.P. Lond., Member of the Court of Examiners, and late Senior Examiner in Arts at Apothecaries' Hall, &c.; "Outlines of Theoretical Chemistry," by Lothar Meyer, Professor of Chemistry in the University of Tübingen, translated by Profs. P. Phillips Bedson and W. Carleton Williams (this book, of about 200 pages, gives a concise account of the theories of modern chemistry, which, it is expected, will not only be of use to advanced students, but will also enable those who take a general interest in science, but are unfamiliar with the details of chemical investigation, to gain a general idea

of the development of theoretical chemistry); "The Dynamics of Rotation," by A. M. Worthington, Professor of Physics, and Head Master of the Dockyard School, Portsmouth; "The Principles of Chemistry," by D. Mendeleéff, Professor of Chemistry in the University of St. Petersburg, translated by George Kamensky, A.R.S.M. of the Imperial Mint, St. Petersburg, and edited by A. J. Greenaway, Sub-Editor of the Journal of the Chemical Society, 2 vols.; "A Manual of the Science of Religion," by Prof. Chantepie de la Saussaye, translated by Mrs. Colyer Fergusson (*née* Max Müller), revised by the author; "Solutions: being an English Translation (by M. M. Pattison Muir) of Book IV. Vol. I. of the Second Edition of Prof. Ostwald's 'Lehrbuch der allgemeinen Chemie.'"

Messrs. Smith, Elder, and Co. have in preparation "Vertebrate Embryology," by A. Milnes Marshall, F.R.S., Professor in the Victoria University, Beyer Professor of Zoology in Owens College, late Fellow of St. John's College, Cambridge; new, revised, and cheaper edition of Finlayson's "Clinical Manual"; new edition of Farquharson's "Guide to Therapeutics"; new edition of Part I. of MacCormac's "Surgical Operations."

Messrs. Sampson Low, Marston, and Co. announce: "Theory and Analysis of Ornament," applied to the work of elementary and technical schools, by François Louis Schauermann, for eight years Head Master of the Wood and Carving Department, Royal Polytechnic, Regent Street, with 263 illustrations; "Answers to the Questions on Elementary Chemistry," theoretical and practical (ordinary course), set at the examinations of the Science and Art Department, South Kensington, 1887–91, by John Mills, formerly of the Royal College of Science, London, author of "Alternative Elementary Chemistry," fully illustrated; "Chemistry for Students," consisting of a series of lessons based on the Syllabus of the Science and Art Department, and specially designed to facilitate the experimental teaching of elementary chemistry in schools and evening classes, by John Mills, author of "Alternative Elementary Chemistry," &c., numerous illustrations; "A Complete Treatise on the Electro-Deposition of Metals," comprising electro-plating and galvanoplastic operations, the deposition of metals by the contact and immersion processes, the colouring of metals, the methods of grinding and polishing, &c., translated from the German of Dr. George Langbein, with additions by William T. Brannt, editor of "The Techno-Chemical Receipt Book," &c., illustrated by 125 engravings; "Handwriting in Relation to Hygiene," being a paper read at the Seventh International Congress of Hygiene and Demography, London, 1891, by John Jackson, and the Report of the Commission of Specialists appointed by the Imperial and Royal Supreme Council of Health, Vienna, 1891.

The next volume of the Contemporary Science Series, published by Mr. Walter Scott, will be "The Man of Genius," by Prof. Lombroso; this volume, which will be issued on September 25, will be copiously illustrated.

Messrs. Blackie and Son have in the press a "Text-book of Agriculture," under the editorship of Prof. R. P. Wright, of the Glasgow and West of Scotland Technical College; they have also in preparation a series of "Guides to the Science Examinations" (the first number, which is nearly ready, is by Mr. Jerome Harrison, of Birmingham, and deals with the examinations in physiography); Pinkerton's "Mechanics," in their series of Science Text-books, is about to enter a second edition, and the opportunity is being taken to adapt it to the revised requirements of the 1891 Syllabus of the Science and Art Department.

Messrs. A. and C. Black have in preparation: "Manual of Chemistry," by Dr. Alexr. Scott, Durham; "Manual of Botany," by Dr. Scott, Bickley; "Dictionary of Birds," by Prof. Alfred Newton and Dr. Gadow.

Messrs. Whittaker and Co. announce the following books:—In Whittaker's Library of Popular Science—"Light," by Sir H. Trueman Wood, Secretary of the Society of Arts, 86 illustrations, containing chapters on the Nature of Light, Reflection, Refraction, Colour and the Spectrum, Lenses, Optical Instruments, &c.; "The Plant World: its Past, Present, and Future," by George Massee, with numerous illustrations. In Whittaker's Specialist's Series—Prof. Oliver Lodge's work upon "Lightning Conductors and Lightning Guards"; "The Alkali Maker's Hand-book," by Prof. Dr. George Lunge and Dr. F. Hurter, a new, revised, and enlarged edition; "Electric Light Cables and the Distribution of Electricity," by Stuart A. Russell; "The Artificial Production of Cold," by H. G. Harris; "The Dynamo," by C. C. Hawkins and J. Wallis; "The Drainage of Habitable Buildings," by W. Lee Beardmore, Member of the Council and Hon. Sec. of the Civil and Mechanical Engineers' Society; a fourth revised and enlarged edition of "The Working and Management of an English Railway," by G. Findlay, General Manager of the London and North-Western Railway; "The Working and Management of an Atlantic Liner; with a Retrospect of the Trade," by A. J. Maginnis, recently Assistant Superintendent of the White Star Line. In Whittaker's Library of Arts, Sciences, Manufactures, and Industries—"A First Book of Electricity and Magnetism," by W. Perren Maycock; "The Practical Telephone Hand-book and Guide to Telephonic Exchange," by J. Poole, Whitworth Scholar, 1875, late Chief Electrician to the Lancashire and Cheshire Telephone Exchange Co., with 227 illustrations; "The Optics of Photography and Photographic Lenses," by J. Traill Taylor, editor of the *British Journal of Photography*; "The Art and Craft of Cabinet-making," by D. Denning, with upwards of 200 illustrations.

Messrs. Cassell and Co. announce:—"Geometrical Drawing for Army Candidates," by H. T. Lilley, new and enlarged edition; "A First Book of Mechanics for Young Beginners," with numerous easy examples and answers, by the Rev. J. G. Easton, late Scholar of St. John's College, Cambridge, formerly Head Master of the Grammar School, Great Yarmouth; "Work," yearly volume, an illustrated magazine of practice and theory for all workmen, professional and amateur; "The Principles of Perspective as Applied to Model-Drawing and Sketching from Nature," with 32 plates and other illustrations, by George Trobridge, Head Master Government School of Art, Belfast, second edition, revised and enlarged.

SCIENTIFIC SERIALS.

American Journal of Science, September.—On the capture of comets by planets, especially their capture by Jupiter, by H. A. Newton. The full paper is not now given. The completed results will be noted in Our Astronomical Column as soon as they are published.—Pleistocene fluvial planes of Western Pennsylvania, by Frank Leverett. Some facts are stated which clash with certain conclusions drawn by Mr. P. Max Foshay in a paper entitled "Pre-Glacial Drainage and Recent Geological History of Western Pennsylvania," which appeared in the November number of the *Journal*. From these it appears that the obstacles to a northward discharge of the Shenango, Mahoning, and Beaver are, on the whole, greater than those in the way of a southward discharge. In the Monongahela, Lower Allegheny, and the Ohio valleys, the available evidence all indicates southward discharge along the present course of the Ohio from the inter-Glacial period to the present time.—A method for the determination of antimony and its condition of oxidation, by F. A. Gooch and H. W. Gruener.—A method for the estimation of chlorates, by F. A. Gooch and C. G. Smith.—Dampening of electrical oscillations on iron wires, by John Trowbridge. The experiments lead to the conclusions that (1) The magnetic permeability of iron wires exercises an important influence upon the decay of electrical oscillations of high frequency. This influence is so great that the oscillations may be reduced to a half-oscillation on a circuit of suitable self-induction and capacity for producing them. (2) It is probable that the time of oscillation on iron wires may be changed. Only a half-oscillation has been obtained on iron wires, so this law cannot be stated definitely. (3) Currents of high frequency, such as are produced in Leyden jar discharges, therefore magnetize the iron.—Genesis of iron ores by isomorphous and pseudomorphous replacement of limestone, &c., by James P. Kimball. The author adduces a considerable amount of evidence showing that such products of epigenesis as siderite and ferro-calcite are, as a rule, products of direct pseudomorphous replacement of isomorphous calcic carbonate, like limestone, calcite, calc-sinter, calcareous sediments, &c. And the general proposition is therefore advanced that deposits of concentrated iron ores occur far more extensively as pseudomorphous replacements than is usually supposed.—On the constitution of certain micas, vermiculites, and chlorites, by F. W. Clarke and E. A Schneider. Chemical analyses of several specimens are given.—A further note on the age of the Orange Sands, by R. D. Salisbury. Some new facts are stated in support of the view that the Orange Sand series of sands and

gravels are of the pre-Pleistocene age.—Note on the causes of the variations of the magnetic needle, by Prof. Frank H. Bigelow. (See Our Astronomical Column.)—Notice of new vertebrate fossils, by O. C. Marsh.

THE *American Meteorological Journal* for August contains the following articles:—Mountain meteorology, by A. L. Rotch. The author points out the advantages of mountain stations at which regular and continuous observations can be made as compared with fragmentary observations in balloons. The chief characteristic of the pressure at high altitudes in temperate and northern regions is a higher pressure in summer and a lower pressure in winter; thus the barometer varies inversely at high and low levels. With elevation above the sea, the absorption of aqueous vapour diminishes, or inversely, solar radiation increases. In the Himalayas a black bulb thermometer *in vacuo* has registered 25° above the boiling point of water, while the shade temperature was only 75°. In general, the annual range of temperature diminishes with height, so that at an elevation of about 39,000 feet, which is the height of the cirrus clouds, probably the temperature is constant throughout the year. The hygrometric conditions at high altitudes are subject to rapid changes, from complete saturation to extreme dryness, and are accompanied by analogous thermal changes. In all mountainous regions, where there is no prevailing wind there is a wind blowing into the valleys during the day, and out from the valleys during the night. On calm, clear, winter nights the air in the valleys is often colder than on the mountain slopes. The author considers that much of the progress made in recent years in meteorological science is due to the establishment of mountain-stations, and that in comparing the work done by various nations to advance mountain meteorology, France stands unrivalled. The German and Austrian stations are frequently badly placed, being located in inns below the summits. Among the best stations (in addition to the French) he mentions the Sonnblick, Hoch Obir, Säntis, Ben Nevis, and Mount Washington.—On the various kinds of gradients, by L. Teisserenc de Bort. This is a translation from the memoirs of the Meteorological Congress held at Paris in 1889, in connection with the International Exhibition. The air being put in motion by differences of pressure, there ought evidently to be a relation between the gradient and the wind velocity, but although the wind increases with the gradient, there is no exact ratio, nor a constant relation from day to day. The author reviews the subject in connection with changes produced by temperature and dynamic effects upon the rectilinear movements of the atmosphere, and the movements caused by the earth's rotation, and he draws attention to the "dragging" of the air by the friction of the superincumbent layers, the effect of which ought to be revealed by observation.—The climatic history of Lake Bonneville, by R. de C. Ward. This is an abstract of a monograph by J. R. Gilbert, published by the United States Geological Survey. The paper is chiefly geological, but has an important bearing upon the secular changes in climate. Lake Bonneville was the ancestor of the great Salt Lake of Utah, which has frequently altered its level, even in recent years. At the time of the glacial epoch its level was about 300 metres higher, and it occupied about ten times its present area. The cause of the drying up of a large part of the former area is found in the prevailing winds which, on their way from the Pacific and in their passage over the Sierra Nevada, have precipitated much of their moisture, and pass over this region as drying winds.—The other articles are: observations at a distance (by means of electricity), by T. P. Hall; ocean fog (the causes which produce it), by E. P. Garriott; and water-spouts (observed on a voyage), by Prof. C. Abbe.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 31.—M. Duchartre in the chair.—Comparative amatomy of plants, by M. A. Chatin. In presenting this recently published work to the Academy, the author summarizes the results of his researches on Phanerogamic plants contained in it and former volumes.—Studies relative to the comparison of the international metre with the prototype of the *Archives*, by M. Bosscha. It has been experimentally found that, after existence for a century, the metre of the *Archives* may still be used in the production of a unit of length, with all the precision requisite in the measures of a prototype, and that the international metre and national standards defined by the equations sanctioned by the General Conference of Weights and Measures represent a unit of length sensibly different from the *Archives* metre. They are shorter by about 2·6 μ.—On a property of involution common to a plane group having five right angles and a system of nine planes, by M. Paul Serret.—On the laws of hardening and permanent deformations, by M. G. Faurie.—Observation of Wolf's comet, by M. J. Léotard. The comet was observed on August 27 as a feeble nebulosity about 3′ in diameter.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Lessons in Art: Hume Nisbet (Chatto).—The Electro-magnet and Electro-magnetic Mechanism: S. P. Thompson (Spon).—Hand-book of Jamaica, 1891–92 (Stanford).—The South Italian Volcanoes, edited by Dr. Johnston-Lavis (Naples).—The Frog, 4th edition.—A. M. Marshall (Manchester, Cornish).—Publications of West Hendon House Observatory, Sunderland; No. 1, Structure of the Sidereal Universe: T. W. Backhouse (Sunderland, Hills).—Telegraphic Determinations of Longitudes on the West Coast of Africa: Pullen and Finlay (Admiralty).—Electricity in Mining: S. P. Thompson (Spon).—Prize Essay on the Distribution of the Moon's Heat and its Variation with the Phase: F. W. Very (The Hague, Nijhoff).—Return, British Museum (Eyre and Spottiswoode).—Ueber den Beweis des Prinzips von der Erhaltung der Energie: T. Gross (Berlin, Mayer and Müller).—Geological Magazine, September (K. Paul).—Zeitschrift für Wissenschaftliche Zoologie, 52 Band, 3 Heft (Leipzig, Engelmann).—Morphologisches Jahrbuch, 17 Band, 3 Heft (Leipzig, Engelmann).—Encyklopædie der Naturwissenschaften, Dritte Abthg., 10 Lief (Breslau, Trewendt).—Notes from the Leyden Museum, vol. xiii. No. 3 (Leyden, Brill).—Ergänzungsheft zum 68 Jahrest. der Schlesischen Gesellschaft für Vaterländische Cultur (Breslau, Aderholz).—Journal of the Chemical Society, September (Gurney and Jackson).—The Asclepiad, No. 31, vol. 8: Dr. B. W. Richardson (Longmans).

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